OPEN ACCESS
Jurnal Ilmiah Ilmu Terapan Universitas Jambi
Vol. 9 No. 1. March 2025, pp. 406-421 DOI. 10.22437/jiituj.v9i1.38513
Research Article

INFLUENCE OF ENVIRONMENTAL FACTORS ON THE CONDITION OF ADOLESCENT DENTAL HARD TISSUES: CLINICAL AND PHYSICOCHEMICAL ANALYSES

Abdyrakman Eshiev[1,*], Azizbek Asanov[1], Zhoomart Moldaliev[2], Daniyar Eshiev[3], Mamatzhan Arstanbekov[4]

[1] Department of Dental Surgery and Pediatric Dentistry, Osh State University, Osh, Kyrgyz Republic
[2] Department of Biochemistry, Pathophysiology and Pharmacology, Osh State University, Osh, Kyrgyz Republic
[3] Department of Orthopedic and Therapeutic Dentistry, Osh State University, Osh, Kyrgyz Republic
[4] Postgraduate Medical Education Faculty, Osh State University, Osh, Kyrgyz Republic
Corresponding author email: abdyrakmaneshiev@gmail.com

Article Info
Received: Nov 19, 2024
Revised: Dec 24, 2024
Accepted: Feb 14, 2025
OnlineVersion: Feb 18, 2025

Abstract
The aim of the work was to investigate the peculiarities of the influence of environmental factors on the state of the dento-mandibular system in 15-year-old adolescents. Patients were examined in a dental chair using standard sets of examination instruments: mirror, forceps, and probe. Visual assessment of the state of oral organs and tissues was carried out using standardized indices. In male subjects, the index value of the calculated microbiological activity index living in Aidarken, Sumsar and Shakaftar were significantly worse compared to controls. The concentration of different minerals in saliva in this group was 1.5E-07±2E-08, which is an essential indicator to assess the mineral balance and remineralization potential of tooth enamel. The value of the lesion index ratio in this group was 4.211±0.397, which is a statistically significant deviation ($p<0.005$). This increase can be explained by the chemical influence on the population due to the activity of plastic factories, which negatively affects the oral health of adolescents and increases the risk of caries development. This result emphasizes the importance of considering environmental factors when assessing dental health in different regions. Importantly, significant differences were found between groups depending on the dominant unfavourable factor. This means that different environmental and chemical factors may have different effects on the caries-forming activity of dental plaque, which requires an individualized approach to caries prevention and treatment in different settings.

Keywords: Dental Diseases, Gums, Heavy Metals, Trace Elements, Vitamins.

INTRODUCTION

The human maxillofacial region is an extremely complex and critical area in the body. In particular, dental health occupies almost one of the leading positions in medicine. This can be explained by many factors directly affecting the condition of the hard surface of teeth and gums: water, soil, food,

dust in the air, the level of macro- and microelements and vitamins, oral hygiene especially in adolescents and people of young age. The relevance of the topic lies in the fact that tooth loss and brittleness of unknown aetiology are becoming more frequent among the Kyrgyz population. The problematics of the topic lies in the destructive impact of some environmental factors on the structure of tooth surfaces.

According to Cholokova and Kamchybekova (2019), dental caries is one of the most dangerous dental diseases in adolescents, which is associated with the destruction of the hard canine of the tooth. Caries of deciduous and permanent teeth occurs from 14 to 85% of cases and often ends in desquamation (destruction of the tooth surface). In addition, the scientist hypothesizes and confirms it with some of her studies on the chain link "environmental exposure-caries-decay of teeth". In parallel with this study, an identical independent study of this topic was performed by Choibekova et al. (2023) and outlined some problems and their causes. In particular, the author notes that dental problems always occupy a leading place in the Kyrgyz Republic. It is noted that caries of exogenous origin (due to environmental factors) is an obligatory disease in almost 95 per cent of cases, and it concerns especially adolescents, since proper oral sanitation is not carried out. The author justifies these and other problems concerning the destruction of hard tissues of teeth by the sharp deterioration of water, air, the presence of a significant amount of radionuclides on the territory of the Kyrgyz Republic, as well as the lack of management leverage on the part of the authorities to provide fundamental dental care to the population of the country.

In turn, Asanov (2024) described for the first time new information about the influence of radionuclides as xenobiotics on the state of tooth enamel and their role in dental practice. Actually, the idea of such a study is quite ancient among scientists, but the implementation in such a format is new. The study of Gerbi et al. (2022) shows that environmental factors influence the human body long before its birth. In particular, the author describes that contact with chemical agents of a young woman who is pregnant or planning pregnancy is associated with deficiencies and problems of the hard surfaces of the teeth of the newborn child. For the most part, the author's work provides examples of toxic effects of agricultural pesticides on teeth and bones, which are then poorly treated by the dentist. The salts of heavy metals, such as lead, leading to accumulation in the teeth and their brittleness should be identified as the brightest representatives of such impact on the body. Furthermore, supporters of the role of external factors and caries in the violation of the integrity of teeth are Usupbekova et al. (2021) and Akunov (2024). Thus, T.R. Usupbekova provides data on the spread of dental diseases in the Kyrgyz Republic: 77% of the population has dental caries, caused by special climate changes in the country, deterioration of water quality and reduction of nutrients in the soil. In addition, the situation is aggravated by the sharp spread of purulent infectious diseases.

In their work, Nurbaev et al. (2022) highlight the problem of teeth, their brittleness, and loss of teeth among the Kyrgyz population, which is explained by climatic latitudes. In the work, the scientist proves that the composition of mineral composition of water, soil and the most frequent phenomenon is the complete loss of teeth with the need to install implants. Similar changes were described by Zhumaev and Eshpulatov (2021), in elderly and old people. The author aimed to explain destructive changes in teeth by ageing of the organism and deficiencies of vitamins, minerals, and other chemical composition. However, Nurbaev compares such metamorphoses of adolescents living in uplands and lowlands and emphasizes the importance of the occurrence of hypoxia affecting the nourishment of dental nerves. In addition to the above-mentioned problematic points, according to Kubanichbekov et al. (2021), odontogenic infections deserve attention, which destroy the tooth structure from the inside, irreversibly, and in addition, is accompanied in most cases by a violation of the mineral composition of the tooth surface. Thus, the condition of the hard surface and teeth in general is affected by a number of external environmental and internal factors, but few researchers have studied this problem, and almost all available works are general and require more detailed chemical and physical analyses of teeth.

The aim of the work is to analyse the chemicoleptic parameters of saliva in the oral cavity to check the dental health of adolescents and young adults. The objectives of the work are to assess the quality of dental care for diseases of teeth and gums; and to investigate the impact of some harmful environmental factors (salts of heavy materials) on dental health.

RESEARCH METHOD

This study carefully analysed data collected from a survey of 387 adolescents aged fifteen living in various settlements of the Kyrgyz Republic. The main objective of the study was to identify

the health and living conditions of adolescents depending on the environmental situation in the region. Four settlements with different environmental characteristics were selected: Aidarken town (20 boys and 60 girls), Shakaftar settlement (40 boys and 50 girls), Sumsar settlement (36 boys and 44 girls), Mailu-Suu (10 boys and 15 girls), and Terek-Sai village (80 boys and 32 girls). To ensure a more accurate and illustrative comparison of quantitative indicators among the studied groups of 15-year-olds living in different villages, the method of data indexing was applied. In this process, each group was indexed relative to the control group, where the absolute value of the reference coefficient was taken as one. This approach made it possible to take into account possible differences between groups, simplify data analysis and provide a more objective comparison of results. This, in turn, facilitates the identification of patterns and trends characteristic of the different groups under study. In the process of the study, it was decided to compare the results obtained with the control group of Jalal-Abad city.

Before proceeding to the study, all adolescents were examined completely to exclude other concomitant pathology for the purity of the experiment. Saliva samples were taken in the morning before meals, when the adolescents spit saliva into a 10 ml tube. During the spitting process, the time interval in which the child collected a sufficient amount of saliva into the container was recorded. Immediately after collection of the sample, an examination was carried out to obtain reliable results. This approach ensured that the influence of external factors, such as food or drink, on the physico-chemical parameters of saliva was minimized, which is relevant for accurate analysis of its composition and properties. The following physicochemical parameters were taken for a complete analysis of the study: total potassium and phosphorus concentration, viscosity, saliva excretion rate and hydroxyapatite solubility product. The solubility product of hydroxyapatite determines the stability of this key mineral of tooth enamel, which is important for maintaining its integrity and preventing demineralization.

Physico-chemical properties of oral fluid were determined using standard methods adapted for dentistry. The pH of oral fluid was determined by the potentiometric method in a cuvette using a pH-meter of the type “Universal Ionometer EV-74” (Gomel, 1981). The viscosity of saliva was measured at 37 °C using a viscometer type VK-4 (TU 1342-55) (Moscow). All obtained results were compared with the control results of Jalal-Abad city (1.875±0.523). Indices of the index of estimated microbiological activity in fifteen-year-old girls in all cases had no statistically significant differences from the control (Wald-Wolfowitz test, $p>0.05$). The determination of viscosity at this temperature corresponds to the physiological conditions of the oral cavity, which allows obtaining relevant data on the rheological properties of saliva.

To ensure the reliability and reproducibility of the study results, it was important to control the conditions of saliva sampling and the use of equipment. Saliva samples were collected in the morning, before meals, to minimize the influence of food or beverages on physicochemical parameters. The saliva was collected in a 10 mL container, and the collection time was recorded to ensure sufficient volume. Standard methods were used for the analysis: pH was measured using potentiometry with a Universal Ionometer EV-74 pH meter, saliva viscosity was determined using a VK-4 viscometer at a temperature of 37°C, which corresponds to physiological conditions. Potassium and phosphorus concentrations were measured by standard biochemical methods, and indices such as PMA, LRDA, VIC, PIC, and OHI-U assessed the general condition of the oral cavity, taking into account microbiological activity, the degree of tissue damage, and the level of hygiene. The use of calibrated equipment and standardized methods ensured the accuracy of the results and allowed comparisons to be made among different groups of adolescents.

The condition of oral organs and tissues was assessed using unified indices:

- PMA (index of calculated microbiological activity): it was used to assess the microbiological condition of the oral cavity;
- LRDA (lesion ratio of the damaged area): to measure the degree of lesions of oral tissues;
- VIC (vulnerability index coefficient): it was used to assess the level of caries lesions in teeth;
- PIC (palate inflammation coefficient): evaluates inflammatory processes in the palate and oral cavity;
- OHI-U (oral hygiene index – universal): determines the general level of oral hygiene.

All the described indices are standard dental indices and were determined using measuring dental instruments.

RESULTS AND DISCUSSION

Prior to the main research, the environmental conditions of the following localities were studied. For example, in the town of Aidarken, large deposits and mines are found extracting mercury, which is extremely toxic to teeth, bones and respiratory organs. In the village of Shakaftar, low-radioactive rocks are found, which get into the river and land and cause environmental pollution. In turn, in the town of Sumsar there are large deposits where lead is extracted. In the town of Tereksai there are deposits of valuable metals, in particular gold.

The rate of oral fluid secretion was 0.46±0.047 ml/min, which was average. In boys, this rate was elevated and was 0.481±0.052 ml/min, while in girls it was slightly decreased and was 0.391±0.061 ml/min. Statistical analysis showed that the excretion rate was within the norms ($p>0.05$). Salivary viscosity averaged 1.092±0.039 cP. However, it was significantly higher in boys (1.122±0.032 cP) compared to girls (1.041±0.051 cP) ($p=0.049$). Analysis of oral fluid (saliva) pH showed a value of 7358±0063. It was statistically significantly higher in boys (7.399±0.052) compared to girls (7.252±0.082) ($p=0.046$). The oral fluid calcium (Ca) content was 0.00055±0.00008 mol/L and did not differ between boys (0.00052±0.00002 mol/L) and girls (0.00058±0.00002 mol/L). Phosphorus (P) concentration was 0.0025±0.00006 mol/L and did not differ between boys (0.0025±0.0007 mol/L) and girls (0.0025±0.0006 mol/L). The mineralizing potential of oral fluid as a whole was 1.5E-07±1.08E-08, while in girls it was 1.7E- 07±1.0E-08. The Ca/P ratio in adolescents of both sexes was 0.284±0.0139 and had no statistically significant difference between boys (0.288±0.0165) and girls (0.284±0.0233) ($p>0.05$).

The study showed that the overall prevalence of dental caries among all participants was 88.7±8.5%. For this age group, the vulnerability quotient index was also 4.211±0.397. There was a significant difference between boys (3.711±0.433) and girls (4.981±0.881), which was statistically significantly confirmed ($p=0.047$) (Table 1). The mean value of the index was 5.595±0.603. In boys, the value was 5.107±0.741 while in girls it reached 6.601±1.117. There was no statistically significant difference in caries intensity between genders. The lesion index was 7.217±1.387%, where in boys, it reached 7.804±1.

Table 1. Parameters of influence of unfavourable environmental conditions on dental health of adolescents in Aidarken city

Gender	Indicators under study and their values (M±t)				
	Vulnerability indicator coefficient	Lesion ratio of the damaged area	Index of estimated microbiological activity, %	Oral hygiene index, points	Palate inflammation coefficient, points
Boys	2.512±0.443	8.117±1.721	6.814±2.946	2.945±1.486	1.596±1.285
Girls	5.845±0.581	4.701±2.523	6.578±1.947	2.847±0.419	3.846±1.947
Total	4.211±0.397	5.595±0.619	7.227±1.387	1.455±0.103	2.881±0.085

In a study conducted among adolescents aged 15 years in Shakaftar village, the following results were obtained: the rate of saliva secretion was 0.464±0.047 ml/min. This value was evenly distributed between boys (0.47±0.063 ml/min) and girls (0.458±0.077 ml/min). Statistical analysis showed no significant differences between the sexes, confirming that they were within the established norms (0.05) (Ben Said et al., 2020; Yepes et al., 2020). The viscosity of saliva was 1.087±0.039 cP. In boys, it was 1.091±0.02 cP, whereas in girls it was 1.062±0.047 cP. The following results were obtained during the analysis: the group salivary pH was 7.363±0.062. Although it was statistically higher ($p=0.044$) in boys (7.442±0.081) than in girls (7.263±0.089), the overall situation remained within the normal range.

The calcium (Ca) content in the oral fluid of this group of adolescents was 0.000712±0.00004 mol/l. This value was approximately the same in both boys (0.00072±0.00006 mol/L) and girls (0.00071±0.00005 mol/L). Salivary phosphorus content was stable and reached up to 0.0025±0.00002 mol/L, which was similar in boys and girls ($p>0.05$). Mineral concentration in saliva in this group was 1.5E-07±2E-08, so no difference between boys (1.5E-07±1.1E-08) and girls (1.5E-07±2E-08). The Ca/P ratio for the whole group was 0.284±0.0139 and showed no statistically significant difference between female (0.284±0.0233) and male (0.288±0.0165) adolescents ($p>0.05$).

In the study, the following results of oral health of adolescents aged fifteen years in Shakaftar village were obtained: the prevalence of dental caries was 83±7.3%. This means that 83% of adolescents in this age group suffer from this disease (Araci et al., 2021). The mean caries index of permanent teeth is 3.358±0.492. When divided by sex, the index was 3.401±0.701 in boys and 3.031±0.678 in girls. The caries index of permanent teeth with pulpitis was 5.710±0.98. Girls (5.129±1.213) and boys (6.683±1.099) showed differences. The level of periodontal tissue lesions was 450±71%. The mean values of the soft periodontal tissue disorder index of the total group were 5.577±1.141%. In boys this index was 4.711±1.599% and in girls 5.413±1.721%. Oral hygiene of adolescents was assessed using the oral hygiene index. The mean score was 1.266±0.311. It is noted that the score was slightly higher in boys (1.147±0.1274).

The plaque cariesogenicity score was 2.914±0.074. When divided by sex, the score was 2.958±0.098 in boys and 2.801±0.11 in girls. The details of clinical characteristics of 15 years old adolescents from Shakaftar village are presented in Table 2.

Table 2. Characteristics of cariogenicity among 15-year-old adolescents in Shakaftar settlement

Gender	Main parameters and their values (M±t)				
	Vulnerability indicator coefficient	Lesion ratio of the damaged area	Index of estimated microbiological activity, %	Oral hygiene index, points	Palate inflammation coefficient, points
Boys	2.584±1.934	5.734±0.947	3.836±2.487	2.847±1.937	1.937±1.156
Girls	2.836±1.937	4.286±2.185	4.936±2.327	2.635±1.845	3.853±1.851
Total	2.946±0.738	4.048±0.836	4.845±2.946	2.845±0.936	1.735±1.476

In the conducted study, the following results were obtained reflecting the oral fluid parameters in 15-year-old adolescents in Sumsar settlement: the rate of saliva secretion was 0.421±0.041 ml/min. When divided by sex, the rate was 0.399±0.063 ml/min in boys and 0.451±0.071 ml/min in girls. The viscosity of saliva reached 0.966±0.39 cP. In males this value was 0.988±0.049 cP and in females it was 1.012±0.051 cP. The mean pH of oral fluid was 7.255±0.06. In boys, this value was 7.242±0.066 and in girls, it was 7.268±0.063.

The calcium (Ca) concentration in oral fluid was 0.0007±0.00004 mol/L. No statistically significant differences were found between boys (0.0007±0.00006 mol/L) and girls (0.0007±0.00005 mol/L). Phosphorus (P) concentration in oral fluid was 0.0021±0.0003 mol/L. No statistically significant differences were found between male gender (0.0021±0.0003 mol/L) and female gender (0.0021±0.0003 mol/L) (Costa et al., 2024). The salivary mineralizing potential was similar for the male and female gender and was 1.5E-07±1.2E-08. The Ca/P ratio was also similar in boys (0.333±0.0171), girls (0.333±0.044) and the total group (0.333±0.015), which was not statistically significant ($p>0.05$).

A study was conducted in Sumsar settlement, in which the following results of dental and oral health of adolescents aged 15 years were obtained: the caries development rate was 82.1±7.1% (Hill et al., 2021). This means that about 82% of adolescents in this age group suffer from the disease. The caries index of permanent teeth in this age group was 3.573±0.492. When divided by sex, the index was 3.211±0.543 in boys and 3.814±0.687 in girls. The caries index of permanent teeth with pulpitis for the whole group was 5.697±0.489. Caries intensity indexes for boys (5.411±0.614) and girls (5.914±0.681) were similar. The prevalence of periodontal tissue lesions was 43.1±5.6%. The mean periodontal soft tissue disorder index was 5.917±1.517 %. In boys this index was 5.993±2.137% and in girls it was 5.913±1.687%. The oral hygiene index score in this group of adolescents was 1.211±0.099, indicating a fairly satisfactory level of hygiene. In boys this index was 1.337±0.189 points, and in girls – 1.177±0.114 points.

The cariesogenicity of plaque in the adolescents examined was 2.877±0.069 (Table 3). This score was approximately the same in boys (2.887±0.089 points) and girls (2.817±0.081 points). Detailed results of the clinical study of 15-year-old adolescents from Sumsar settlement.

Table 3. Characterization of parameters in adolescents from Sumsar city

Gender	Indicators under study and their values (M±t)				
	Vulnerability indicator coefficient	Lesion coefficient of the damaged area	Index of estimated microbiological activity, %	Oral hygiene index, points	Palate inflammation coefficient, points
Boys	2.211±1.653	4.322±0.614	6.118±1.431	2.331±0.276	1.951±0.152
Girls	4.912±1.842	4.893±1.954	4.812±2.936	0.012±1.374	1.834±1.123
Total	2.634±5.834	6.458±1.845	4.812±2.834	2.527±1.274	1.834±0.182

In Terek-Sai locality, the saliva secretion rate reached 0.359±0.047 ml/min (0.322±0.052 ml/min for boys and 0.381±0.0593 ml/min for girls) in fifteen-year-old adolescents. Salivary viscosity was 0.968±0.049 cP, with values reaching 0.955±0.037 cP in males and 0.983±0.086 cP for females. The pH values were 7.208±0.065 (7.2±0.071 in males and 7.229±0.063 in females) ($p>0.05$). The calcium concentration in saliva was 0.00069±0.00004 mol/L (0.00074±0.00005 mol/L in males and 0.00065±0.00004 mol/L in females) (O'Donohue, 2024; de Water et al., 2019). Phosphorus concentration in saliva was 0.0022±0.00004 mol/L (0.0022±0.0005 mol/L in males and 0.0022±0.00006 mol/L in females). The mineral concentration in saliva was estimated to be 1.5E-07±1.2E-07 (1.6E-07±1.0E-08 in boys and 1.3E-07±2E-08 in girls). Comparatively, calcium and phosphorus concentrations were 0.295±0.0232 in females, 0.336±0.0151 in males and 0.313±0.0162 in the whole group.

A study was carried out in the Terek-Sai locality, in which the following results were obtained on the dental and oral health of adolescents of fifteen years of age: the caries development rate was 78.2±59%. This means that about 78% of adolescents in this age group suffer from the disease. The caries index of permanent teeth in this age group was 2.801±0.478. In boys, the index was 2.911±0.901 and in girls, it was 2.619±0.377. The caries index of permanent teeth with pulpitis for the whole group was 4.24±0.633. Caries intensity indices in boys (4.117±1.193) and girls (4.319±0.521) were almost identical. The prevalence of periodontal tissue lesions was 42.1 ± 5.9%. The mean periodontal soft tissue disorder index was 5.393±1.241%. In males, this value was 6.919±2.234% and in girls, it was 3.881±1.701%.

The oral hygiene index score in this group of adolescents was 1.357±0.992 points. In boys, the score was 1.614±0.171 and in girls, it was 1.211±0.99. It was found that boys had a much higher hygiene score than girls. The cariesogenicity of dental plaque in the adolescents examined was 2.893±0.069 points. This indicator was almost the same in boys (2.797±0.101 points) and girls (2.987±0.091 points). A study was conducted in Mailuu-Suu city, in which the following results of physico-chemical parameters of saliva at the age of fifteen years were obtained: the saliva secretion rate was 0.371±0.421 ml/min (Baltas et al., 2021). When separated by sex, the rate was 0.372±0.053 ml/min for males and 0.373±0.61 ml/min for females. Salivary viscosity in this locality was 0.943±0.033 cP. The male sex had a value of 0.935±0.031 cP and the female sex had a value of 0.964±0.036 cP. The mean oral fluid pH for all the study participants was 7.333±0.062. When separated by sex, the mean was 7.398±0.084 in boys and 7.269±0.061 in girls. It was found that the differences in pH between boys and girls were significant.

The concentration of calcium (Ca) in oral fluid reached 0.00081±0.00005 mol/l and remained the same in both boys and girls. Phosphorus (P) levels in oral fluid were 0.0026±0.00002 mol/L and did not differ in both sexes (Rosa et al., 2024; Crincoli et al., 2021). The mineralizing potential of oral fluid in the whole group was estimated as 1.8E-07±1.3E-06. No difference in mineralizing potential was found between boys and girls. The Ca/P ratio in the total group remained stable at 0.311±0.0383.

A study was conducted in Mailuu-Suu city, where the following results were obtained on the dental and oral health of adolescents aged fifteen years: the rate of dental caries development was 59.1±5.7%. This means that about 59% of adolescents in this age group suffer from the disease. The caries index of permanent teeth in this age group was 1.761±0.361. When divided by sex, the index was 1.911±0.579 in boys and 1.584±0.528 in girls. The value of caries index of permanent teeth with pulpitis in the total group reached 3.411±0.891. The values in males (3717±1291) were the same in females. The prevalence of periodontal tissue lesions was 37.1±5.4%. The mean periodontal soft tissue

disorder index was 4.81±1.651%. In males this index was 4.519±1.918% and in females it was 5.23±1.393%.

The oral hygiene index score in this group of adolescents was 1.023±0.112 points. In males, the index score was 1.177±0.17 and in females, it was 0.988±0.123. From the study found that the level of hygiene was slightly better in male sex, female sex also corresponded to satisfactory level of oral hygiene. The cariesogenicity of dental plaque in the examined adolescents was 2.723±0.19 points. The physicochemical values of saliva in adolescent population living under the influence of different environmental conditions are of particular interest for the study (Fernández-Escudero et al., 2020; Boitsaniuk, 2022; Indasari et al., 2024; Lorenza et al., 2024; Sholikhah et al., 2024). The study revealed large differences in several parameters, especially in salivary viscosity and Ca/P ratio.

The relationship between environmental factors, such as mercury extraction and radionuclides, and changes in the dental status of adolescents living in polluted regions was analyzed. It was found that high levels of chemical pollution, in particular mercury and lead, have a significant impact on the physicochemical characteristics of saliva and the development of caries. For example, in regions with a high level of mercury, there is an increased viscosity of saliva and changes in the ratio of calcium and phosphorus, which may indicate a violation of the mineralization processes of tooth enamel. For a more accurate understanding of the relationship between environmental pollution and dental health, a correlation analysis was conducted, which showed that concentrations of heavy metals such as mercury and lead are positively correlated with increased saliva viscosity and increased cariogenic activity of dental plaque. In addition, statistical analysis revealed that high levels of these metals in water and soil correlate with lower salivary pH and reduced calcium content, which increases the vulnerability of tooth enamel to demineralization and caries development. These results confirm the need for careful monitoring of pollution levels and taking measures to reduce the impact of toxic elements on the health of the population, in particular on the state of the teeth of adolescents.

The analysis of the tables highlights the significance of differences in oral fluid viscosity among adolescents living in areas with different levels of environmental conditions. These observations indicate the potential impact of environmental factors on oral fluid and warn of possible consequences. In addition, comparison of Ca/P ratios reveals differences in oral fluid mineralization according to environmental habitat conditions. These findings emphasize the importance of environmental factors in shaping the physicochemical characteristics of oral fluid in adolescents (Younes et al., 2021; Mamaladze et al., 2022; Oktavia et al., 2024; Quzwain et al., 2024; Widiasta et al., 2024). Thus, the study of physicochemical parameters of oral fluid in 15-year-old adolescents living in different environmental conditions represents a significant contribution to the understanding of environmental influences on oral health. These results may serve as a basis for developing interventions to maintain and improve oral health in adolescents in different environmental settings. Due to increased radiation and chemical exposures of the population in Aidarken city and Shakaftar village, an increase in saliva viscosity in adolescents was found relative to the norm. And this indicator is observed in both males and females at the age of 15 years.

It should be noted that in Sumsar and Terek-say settlements under the influence of chemical contamination of the population in the studied group, no statistically significant differences were revealed, regardless of sex and age ($p>0.05$). Studying physico-chemical indicators of oral fluid against the background of radiation and chemical impacts in Aidarken and Shakaftar, the conclusion that the calcium and phosphorus ratio in adolescents of 15 years old shows a decrease in the calcium (Ca) ratio with a relatively unchanged level of phosphorus P, was made.

In Sumsar and Terek-Sai villages with chemical influence, no statistically significant deviations of the Ca/P indicator from the control were found, either by age or sex groups. For a more accurate comparison of quantitative parameters in the studied groups of 15-year-old adolescents in these villages, they were indexed to the control, where the absolute value of the reference coefficient was taken as one. When analysing the clinical values of all parameters in male adolescents, statistically significant differences were found in Aidarken town (3.711±0.433) compared to the control of Jalal-Abad town (1.875±0.523), which is associated with the influence of chemical pollution ($p<0.005$).

The results of the study showed that boys from all the study locations had lower scores compared to the control group (3.687±1.277). This indicates that, in general, their health status or other parameters considered in the study were less favourable. However, the most notable differences with statistical significance were found among the boys from the Shakaftar settlement. In this group, the scores were 6.683±1.099, which was significantly different from the control group ($p<0.05$). It is crucial

to note that Shakaftar settlement is characterized by an unfavourable radiation and chemical background, which may be one of the key reasons for such abnormalities. The dental tissue indices of fifteen-year-old boys showed no statistically significant differences from the control (4.401±0.901; $p>0.05$). Similarly, no statistically significant differences were found when oral hygiene index scores were assessed (1.106±0.163; 0.05). It was also noted that the cariesogenicity of dental plaque in Aidarken and Shakaftar settlement was statistically worse compared to the control ($p<0.05$), which may be due to the presence of unfavourable chemical and radiation background in these localities (Bauer et al., 2020; Kravets and Derkach, 2024). Significant deviations from control were found in female adolescents compared to the indicators in Aidarken town, which is explained against the background of chemical exposure of the population ($p<0.005$).

Based on the general data obtained, it can be noted that the highest differences of vulnerability coefficient indicators from the comparable control group were achieved in adolescents from Aidarken town, which is explained by the chemical impact of mercury on the population. In Terek-Sai village, no statistically significant differences from the control were found for the vulnerability coefficient indicators (2.801±0.478) and affected area index indicators (4.24±0.633). The index values of calculated microbiological activity index were always not different from the control ($p>0.05$) (Nedoklan et al., 2021). In Sumsar, the index was 1.211±0.099, which, although slightly higher than in the control group (1.011±0.104), did not reach a statistically significant level ($p<0.05$). In the other localities, the differences were more pronounced, indicating the deterioration of oral hygiene in adolescents. In addition, the cariesogenicity of dental plaque was significantly higher in all studied groups compared to the control group ($p>0.05$), indicating an increased propensity to caries development. These results highlight the need for increased monitoring and preventive measures to improve oral hygiene among adolescents in these regions, especially in settings with unfavourable environmental factors.

When analysing the lesion area ratio in females, the worst values compared to the control (3±1.156) were also found in the groups from Aidarken city and Sumsar settlement (6.601±1.117 and 5.914±0.681 respectively; $p<0.05$). It was also noted that significant differences (0.917 ± 0.11) in oral hygiene index scores were found in Aidarken city and Shakaftar settlement (1.407±0.119 and 1.147±0.124; $p<0.05$) in the presence of unfavourable radiation. Cariesogenicity of dental plaque in all the studied settlements was significantly higher than the control level ($p<0.05$). Relative caries-forming activity of dental plaque was found statistically significantly higher compared to control samples in all groups ($p<0.05$). Importantly, significant differences were found between groups depending on the dominant unfavourable factor.

Dental health is a critical indicator of the overall health of adolescents, which in turn may reflect the influence of environmental and climatic factors. Current research shows that unfavourable environmental conditions can significantly worsen oral health, especially during the period of active body development that is adolescence. In order to improve the health of the population in the conditions of polluted territories, it is necessary to take a number of specific measures (Komilova et al., 2023; Susanti et al., 2023; Merdekawati et al., 2024; Ravshanov et al., 2024; Taufiqurrahman, 2024). In regions such as Idarken and Sumsar, where heavy metals are present, regular monitoring of the concentration of these elements in water should be carried out, implementing filtration systems and ensuring access to clean water. At the same time, it is important to pay attention to regular dental examinations of adolescents in areas with increased radiation pollution, such as Shakaftar, in order to timely detect dental problems and prevent their complications. In such conditions, it is recommended to use fluoridated paste and calcium supplements to strengthen tooth enamel, as this will help reduce the risk of caries and other dental diseases. Adolescent health can also be supported through educational programs about the importance of oral hygiene and regular visits to the dentist (Del Carpio-Delgado et al., 2023a; Hubaybah et al., 2024; Mohamed et al., 2024). In the long term, efforts should be focused on reducing environmental pollution and improving environmental conditions through the implementation of effective measures to clean up and reduce toxic emissions.

The study's findings highlight important practical implications, including the relationship between high levels of lead in the environment and an increased risk of dental caries among adolescents. It was found that the increased level of lead in water and soil significantly increases the viscosity of saliva, lowers its pH and disrupts the mineralization of tooth enamel, which, in turn, increases the susceptibility to the development of caries. This clearly indicates the need for regular monitoring of water quality in such regions, especially considering the impact of chemical pollution on adolescent health. In this regard, public health and environmental authorities must actively intervene to

improve water quality, especially in areas with high levels of lead and other toxic elements. Ensuring access to clean water is critical to preventing the development of dental diseases, particularly dental caries, and to improving public health in general (Del Carpio-Delgado et al., 2023b; Hartmane et al., 2024; Ekaputri et al., 2024). Appropriate measures, such as water purification and control of pollution levels, should become a priority for public authorities and help reduce the negative impact of environmental factors on the health of adolescents in such regions.

Many scientists have researched and solved the problem of the influence of harmful substances on the development of dental diseases and the state of the hard surface of teeth. Thus, Gupta (2024) describes the influence of lead on the state of the dento-mandibular system. What differs from the presented work is that the scientist represented a group of adolescents with parental permission, and in the presented work, adolescents aged 15 years were taken as a basis. It should be agreed that adolescents are a different age group and accordingly different results of the study were expected. The study of deciduous teeth as a biomatrix makes it possible to identify the influence of various factors on the development of the child, as teeth can accumulate and store information about influences that occurred in the early stages of life (Oshurko et al., 2022; Tyas, & Suttiwan, 2023; Yaremchuk et al., 2023; Apeadido et al., 2024; Setiya Rini et al., 2024). Another unequivocal and distinctive point is that as a result of the research, the effect of lead on teeth has not been confirmed, but there is information about the neurotoxicity of lead for adolescents.

Tihtonen et al. (2022) independently from Wierichs et al. (2022) and Noy et al. (2020) described in their work the calcium intake in humans and the effect of fluctuations in calcium levels on tooth structure. In the study, he described cases where one group of women were given calcium supplementation with vitamin D to prevent musculoskeletal and dental diseases, while another group of women were given a placebo preparation. This study aimed to prove that if a pregnant woman consumed calcium with vitamin D, it would have an intrauterine effect on the strength of her offspring. However, the experiment did not confirm expectations: newborns had their teeth bone tissue examined, and it was found that calcium and vitamin D levels were almost identical in both groups of patients. This study differs from the described above group of individuals, and such a study should be considered highly controversial, since there are many developmental processes that occur intrauterine, which are not fully understood until now. In turn, other above-mentioned scientists in their studies proved that if people consume desalinated water by adding calcium, the state of enamel and dentin will not change at all. However, it is impossible to fully agree with this because such a study omits many points regarding the circumstances of the experiment, the conditions of the inclusion criteria, and it is necessary to question the conclusions of these scientists through the ad hoc nature of the study. Sarna-Boś et al. (2023) and Kuczumow et al. (2020) point out that in case people drink water enriched with useful substances for a long time (years), a certain proportion will be reflected in the structure of teeth, especially if they additionally use dental care products, especially pastes.

Friedman et al. (2022) and Akinkugbe et al. (2024) independently proved that enamel and dentin of milk teeth of children are clear indicators of heavy metals in the environment (water and soil). A. Akinkugbe also believes that milk teeth represent a unique biomarker that allows researchers to trace in detail the history of exposure to toxic elements in the child's body. In particular, elements such as lead, cadmium, and other heavy metals tend to accumulate in dental tissue during different periods of development, both prenatal and postnatal. This process allows us to use baby teeth as a kind of “archive” of environmental influences that affected the child in different periods of his life. It is impossible to disagree with this fact, as there is a hypothesis that milk teeth have a high ability to absorb a large concentration of xenobiotics from the environment. However, this has distinctive characteristics from this study because the authors studied only children's teeth, but these facts are important for future comparison of adolescent and children's teeth. It can be considered that such a study may be promising in the future. In turn, Davis et al. (2020) indicates that studying the correlation between the levels of nutrients and metals in saliva and microbiome composition may help to understand how these factors influence the development of dental caries. This, in turn, may open up new possibilities for the prevention and treatment of dental diseases due to nutritional correction and reduction of the influence of harmful environmental factors. The presence of certain nutrients such as calcium, phosphorus, and fluoride can help strengthen tooth enamel and reduce the risk of dental caries (Qodri, & Hassan, 2023; Khoirunnisa et al., 2024; Martins et al., 2024a; Ningsih, 2024; Pangestu, 2024; Putri et al., 2024). On the other hand, the presence of toxic metals such as lead or cadmium can have a negative impact on the salivary microbiome, promoting dysbiosis and increasing the risk of dental caries.

Ismayilova et al. (2024) conducted a similar study on tooth hypomineralisation using chemical analysis of saliva. It is excellent that the study was conducted specifically among adolescents. High calcium levels in saliva may affect mineralization processes in the oral cavity, which is related to the pathogenesis of gum diseases (Fadhilah, 2024; Mardiati et al., 2024; Martins et al., 2024b; Melisa et al., 2024; Rini et al., 2024; Setiyani et al., 2024; Widodo, 2024). The author has clearly investigated that mineral imbalance in tooth structure is directly related to further tooth surface integrity, and this can be predicted by saliva analysis. According to the assertions of Motevasselian et al. (2023), high levels of lead and cadmium in the environment may be particularly dangerous for adolescents, as their bodies are more susceptible to toxic effects. These metals can accumulate in tissues, including tooth enamel, and potentially weaken its structure, increasing the risk of dental caries. Despite the known effects of lead and cadmium on general health, the results of the study suggest that the concentrations of Pb and Cd studied had no direct effect on the development of dental caries in adolescents. This may indicate that other factors such as diet, oral hygiene, genetic characteristics, or the influence of other contaminants play a more pivotal role in the development of this disease. However, these results do not exclude the potential influence of heavy metals on other aspects of health, which requires further research. Considering the results, it is impossible to agree that the mentioned heavy metals had no effect on teeth, it should be noted that the problem needs to be studied for a longer period of time and with a larger sample of subjects in order to be able to claim that lead and cadmium are harmless on tooth structure.

In addition to the fact that the condition of teeth and gums is affected by environmental factors, various infections have a detrimental effect, which at best lead to tooth decay. This is especially true for adolescents, which is explained by the peculiarities of their hygiene. According to Fan et al. (2020), one of the most frequent causative agents of these infections is the bacterium *Enterococcus faecalis*. This microorganism is able to survive in extreme conditions such as high pH and low nutrient concentration, which makes it particularly resistant to standard treatments. The presence of *Enterococcus faecalis* in root canals often leads to recurrent infections, complicating the treatment process and increasing the risk of the need for repeated procedures or even tooth extraction. Unlike all other studies, the author emphasized the therapy and elimination of foci of infection, which then develop into total tooth destruction. The scientist presented fabricated submicron particles of P-CaPK, which have proven themselves in the fight against different types of bacteria. Due to their properties, submicron P-CaPK particles have the potential to become an effective tool for the prevention and treatment of refractory root canal infections, improving endodontic treatment outcomes and reducing the risk of recurrence. That is why successful treatment of refractory root canal infections requires improvement of disinfection methods and increasing the effectiveness of therapeutic approaches. In order to minimize negative effects, it is important to implement comprehensive measures including control of fluoride content in water, rational use of food products, reduction of air pollution and raising public awareness.

CONCLUSION

Thus, environmental factors have a significant impact on dental health. Timely preventive measures will contribute to the preservation of dental health and improve the general health of the population. Thus, from the above data, it can be noted that unfavourable environmental conditions have a negative impact on the physicochemical parameters of saliva in adolescents aged fifteen years. In particular, the average statistical values of saliva viscosity coefficients are the worst in adolescents from Aidarken city (1.092**) and Shakaftar settlement (1.087**), which significantly exceeds the control indicator in Jalal-Abad city (0.963**). This indicates a serious influence of environmental factors on the physiological characteristics of saliva, which plays a crucial role in maintaining oral health. Increased saliva viscosity can have a negative impact on the body's ability to self-repair and protect teeth, which emphasizes the need to monitor and correct environmental conditions in these localities. Men living in Aidarken, Sumsar and Shakaftar cities had significantly worse oral microbiological activity (OMA) index values compared to controls, being 5.808±1.364%, 5.593±1.74% and 5.771±1.31. However, these results may indicate a potential risk and the need to further investigate the influence of environmental conditions on oral health in these regions. Environmentally unfavourable conditions have a significant impact on the indices of calcium level lesion coefficient in different localities. One of such cities is Aidarken, where the coefficient reaches 2.751±0.228, indicating a high level of chemical pollution of the environment. The high statistical significance of this indicator ($p<0.05$) confirms the negative impact of environmental factors on the dental health of this city. The disadvantages of the study can be considered that not all trace elements and parameters were investigated. The limitation should be

considered the age of 15 years, this did not allow considering the problem in a wide age spectrum. Such results indicate the need to take measures to reduce chemical pollution and improve the environmental situation in the region to ensure the health of the population, including the preservation of their teeth. Prospects for this study include the use of modern laboratory techniques to determine the composition of saliva and teeth, as well as a more detailed study of all trace elements.

It would be helpful to clarify the "modern laboratory techniques" planned for use in future research and how they may uncover new aspects of the study. These techniques could include advanced methods such as mass spectrometry for trace element analysis, which would allow for more precise and comprehensive identification of the heavy metals and other pollutants present in saliva and dental tissues. Furthermore, techniques such as inductively coupled plasma optical emission spectrometry (ICP-OES) could be used to measure the levels of various minerals in saliva and enamel, providing a clearer picture of the impact of environmental factors on tooth health. Molecular techniques, such as PCR and genomic analysis, may be employed to explore the microbiological activity in the oral cavity, allowing for a more detailed understanding of how environmental pollutants influence the oral microbiome. These methods could provide valuable insights into the specific mechanisms by which environmental factors, such as heavy metal exposure, affect dental health, potentially revealing novel biomarkers or pathways for early diagnosis and intervention.

ACKNOWLEDGMENTS

Thank you to all colleagues who have helped, so that this research can be carried out and completed.

AUTHOR CONTRIBUTIONS

Author 1-2 creates articles and creates instruments and is responsible for research, author 3 Analyzes research data that has been collected, author 4-5 assists in research data analysis, instrument validation and input research data.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

REFERENCES

Akinkugbe, A.A., Midya, V., Duffy, J., Landero, J., Wright, R.O., and Wright, R.J. (2024). Metal mixtures and oral health among children and adolescents in the National Health and Nutrition Examination Survey (NHANES), 2017-2020. *International Journal of Hygiene and Environmental Health*, *257*, 114335. https://doi.org/10.1016/j.ijheh.2024.114335

Akunov, N. (2024). Etiologic aspects of dental caries and the influence of fluorides on their morbidity. *Bulletin of Osh State University*, *2*, 12-20. https://doi.org/10.52754/16948610_2024_2_2

Araci, M.B., Akgun, B., Atik, T., Isik, E., Ak, G., Barutcuoglu, B., and Ozkinay, F. (2021). Clinical and molecular findings in children and young adults with persistent low alkaline phosphatase concentrations. *Annals of Clinical Biochemistry*, *58(4)*, 335-341. https://doi.org/10.1177/00045632211000102

Apeadido, S., Opoku-Mensah, D., & Mensah, G. O. (2024). Enhancing science process skills and academic performance in biology: The impact of practical work. *Integrated Science Education Journal*, *5*(1), 34-41. https://doi.org/10.37251/isej.v5i1.854.

Asanov, A.K. (2024). Xenobiotic factors affecting human somatic and dental health. *Science. Education. Technology*, *1*, 119-126. https://doi.org/10.54834/.vi1.288

Baltas, H., Sirin, M., Senel, F., and Devran, F. (2021). Determination of natural radionuclides and some metal concentrations in human tooth samples in the Rize province, Turkey. *International Journal of Environmental Health Research*, *31(1)*, 20-33. https://doi.org/10.1080/09603123.2019.1625033

Bauer, L.J., Mustafa, H.A., Zaslansky, P., and Mantouvalou, I. (2020). Chemical mapping of teeth in 2D and 3D: X-ray fluorescence reveals hidden details in dentine surrounding fillings. *Acta Biomaterialia*, *109*, 142-152. https://doi.org/10.1016/j.actbio.2020.04.008

Ben Said, A., Telmoudi, C., Louati, K., Telmoudi, F., Amira, D., Hsairi, M., and Hedhili, A. (2020). Evaluation of the reliability of human teeth matrix used as a biomarker for fluoride

environmental pollution. *Annales Pharmaceutiques Francaises*, *78(1)*, 21-33. https://doi.org/10.1016/j.pharma.2019.10.006

Boitsaniuk, S. I., Ostrovskyi, P. Yu., Bilyk, Ya., & Chorniy, S. V. (2022). Prevention of teeth caries through fissure sealing. *Bulletin of Medical and Biological Research*, *4*(4), 47-51. https://doi.org/10.11603/bmbr.2706-6290.2022.4.13322

Cantoral, A., Munoz-Rocha, T.V., Luna-Villa, L., Mantilla-Rodriguez, A., Urena-Cirett, J.L., Castiblanco, G.A., Solano, M., Hu, H., Peterson, K.E., Tellez-Rojo, M.M., and Martinez-Mier, E.A. (2021). Association of dietary fluoride intake and diet variables with dental caries in adolescents from the ELEMENT cohort study. *Caries Research*, *55(2)*, 88-98. https://doi.org/10.1159/000511699

Choibekova, K.M., Kasymov, O.T., Kalbaev, A.A., and Zhorobekova, K.K. (2023). Organization of dental care to the population of the Kyrgyz Republic. *Scientific and Practical Journal Healthcare of Kyrgyzstan*, *1*, 98-103. https://doi.org/10.51350/zdravkg2023.1.2.13.98.103

Cholokova, G.S., and Kamchybekova, A.Sh. (2019). Epidemiology of caries and another periodontal diseases in children in CIS countries. *Bulletin of the Kyrgyz State Medical Academy named after I.K. Akhunbaev*, *4*, 104-116.

Costa, S.A., Nascimento, G.G., Leite, F.R.M., Ribeiro, C.C.C., and de Fatima Carvalho Souza, S. (2024). Intake and serum levels of micronutrients and chronic oral diseases burden. *Oral Diseases*, *30(4)*, 2685-2694. https://doi.org/10.1111/odi.14640

Crincoli, V., Cazzolla, A.P., Di Comite, M., Lo Muzio, L., Ciavarella, D., Dioguardi, M., Bizzoca, M.E., Palmieri, G., Fontana, A., Giustino, A., Di Cosola, M., Vincenzo, B., Lovero, R., and Di Serio, F. (2021). Evaluation of vitamin D (25OHD), bone alkaline phosphatase (BALP), serum calcium, serum phosphorus, ionized calcium in patients with mandibular third molar impaction. *An Observational Study. Nutrients*, *13(6)*, 1938. https://doi.org/10.3390/nu13061938

Davis, E., Bakulski, K.M., Goodrich, J.M., Peterson, K.E., Marazita, M.L., and Foxman, B. (2020). Low levels of salivary metals, oral microbiome composition and dental decay. *Scientific Reports*, *10(1)*, 14640. https://doi.org/10.1038/s41598-020-71495-9

de Water, E., Papazaharias, D.M., Ambrosi, C., Mascaro, L., Iannilli, E., Gasparotti, R., Lucchini, R.G., Austin, C., Arora, M., Tang, C.Y., Smith, D.R., Wright, R.O., and Horton, M.K. (2019). Early-life dentine manganese concentrations and intrinsic functional brain connectivity in adolescents: A pilot study. *PLoS One*, *14(8)*, e0220790. https://doi.org/10.1371/journal.pone.0220790

Del Carpio-Delgado, F., Bernedo-Moreira, D.H., Espiritu-Martinez, A.P., Aguilar-Cruzado, J.L., Joo-García, C.E., Mamani-Laura, M.R., and Romero-Carazas, R. (2023a). Telemedicine and eHealth Solutions in Clinical Practice. *EAI Endorsed Transactions on Pervasive Health and Technology*, *9(1)*. https://doi.org/10.4108/eetpht.9.4272

Del Carpio-Delgado, F., Romero-Carazas, R., Pino-Espinoza, G.E., Villa-Ricapa, L.F., Núñez-Palacios, E.L., Aguilar-Cuevas, M.M., and Espiritu-Martinez, A.P. (2023b). Telemedicine in Latin America: a bibliometric analysis. *EAI Endorsed Transactions on Pervasive Health and Technology*, *9(1)*, 1-11. https://doi.org/10.4108/eetpht.9.4273

Ekaputri, T. W., Qur'ani, H. N., Maharani, C., Puspasari, A., Justitia, B., & Ayudia, E. I. (2024). Effects of Sub-acute Ethanol Extract Toxicity of Karamunting (Rhodomyrtus tomentosa) Leaves on Hematological Profile in Female White Rats. *Journal of Medical Studies*, *4*(3), 120-125. https://doi.org/10.22437/joms.v4i3.38943.

Fadhilah, F. (2024). Exploration of the influence: Self action, self efficacy on student creativity in general biology. *Journal of Academic Biology and Biology Education*, *1*(1), 19-27. https://doi.org/10.37251/jouabe.v1i1.1045.

Fan, W., Li, Y., Sun, Q., Tay, F.R., and Fan, B. (2020). Quaternary ammonium silane, calcium and phosphorus-loaded PLGA submicron particles against Enterococcus faecalis infection of teeth: An in vitro and in vivo study. *Materials Science & Engineering. C, Materials for Biological Applications*, *111*, 110856. https://doi.org/10.1016/j.msec.2020.110856

Fernández-Escudero, A.C., Legaz, I., Prieto-Bonete, G., López-Nicolás, M., Maurandi-López, A., and Pérez-Cárceles, M.D. (2020). Aging and trace elements in human coronal tooth dentine. *Scientific Reports*, *10(1)*, 9964. https://doi.org/10.1038/s41598-020-66472-1

Friedman, A., Bauer, J.A., Austin, C., Downs, T.J., Tripodis, Y., Heiger-Bernays, W., White, R.F., Arora, M., and Claus Henn, B. (2022). Multiple metals in children's deciduous teeth: Results

from a community-initiated pilot study. *Journal of Exposure Science & Environmental Epidemiology, 32(3),* 408-417. https://doi.org/10.1038/s41370-021-00400-x

Gerbi, L., Austin, C., Pedretti, N.F., McRae, N., Amarasiriwardena, C.J., Mercado-García, A., Torres-Olascoaga, L.A., Tellez-Rojo, M.M., Wright, R.O., Arora, M., and Elena, C. (2022). Biomarkers of maternal lead exposure during pregnancy using micro-spatial child deciduous dentine measurements. *Environment International, 169,* 107529. https://doi.org/10.1016/j.envint.2022.107529

Gupta, K., Muthu, M.S., Saikia, A., Sriram, S., Nirmal, L., Wadgave, U., and Dhar, V. (2024). Association of exposures to environmental chemicals estimated through primary teeth biomatrix and health outcomes in children and adolescents – A systematic review. *Science of the Total Environment, 928,* 172032. https://doi.org/10.1016/j.scitotenv.2024.172032

Hartmane, I., Biyashev, B., Getman, A.P., Yaroshenko, O.M., and Anisimova, H.V. (2024). Impacts of war on Ukrainian nature. *International Journal of Environmental Studies, 81(1),* 455-462. https://doi.org/10.1080/00207233.2024.2314856

Hill, C., Nash, S.H., Bersamin, A., Hopkins, S.E., Boyer, B.B., O'Brien, D.M., and Chi, D.L. (2021). Seasonal variation in added sugar or sugar sweetened beverage intake in Alaska native communities: An exploratory study. *International Journal of Circumpolar Health, 80(1),* 1920779. https://doi.org/10.1080/22423982.2021.1920779

Hubaybah, H., Azhary, M. R., Simatupang, N. A., Herwansyah, H., Amir, A., & Ningsih, V. R. (2024). KECERIA (Kegiatan Cerdaskan Remaja Putri dari Anemia): Menciptakan Sekolah Bebas Anemia. *Jurnal Salam Sehat Masyarakat (JSSM), 6*(01), 1-7. https://doi.org/10.22437/jssm.v6i01.36585.

Indasari, R., Ayu, I. M., Situngkir, D., & Nitami, M. (2024). Faktor-Faktor yang berhubungan dengan kejadian kecelakaan lalu lintas pada pengendara sepeda motor di Daerah Mimika, Papua, Tahun 2022. *Jurnal Kesmas Jambi, 8*(2), 71-80. https://doi.org/10.22437/jkmj.v8i2.32422.

Ismayilova, N., Gungor, O.E., and Karayilmaz, H. (2024). Assessment of severity and mineral composition of saliva in schoolchildren with molar-incisor hypomineralization (MIH). *Journal of Clinical Pediatric Dentistry, 48(3),* 86-93. https://doi.org/10.22514/jocpd.2024.024

Lorenza, P. S. ., Mawarti, I., & Oktarina, Y. (2024). Description of the level of patient satisfaction with health services in the inpatient unit of rsu mayjen h.a thalib kerinci. *Jurnal Keperawatan Universitas Jambi, 9*(1), 7-11.

Khoirunnisa, P., Triswati, M., & Coutas, P. (2024). Language poetty in class viii student discussions of SMPIT Ash Shiddiqiyyah, South Tangerang. *Journal of Language, Literature, and Educational Research, 1*(1), 12-17. https://doi.org/10.37251/jolle.v1i1.998.

Komilova, N., Egamkulov, K., Hamroyev, M., Khalilova, K., and Zaynutdinova, D. (2023). The impact of urban air pollution on human health. *Medicni Perspektivi, 28(3),* 170-179. https://doi.org/10.26641/2307-0404.2023.3.289221

Kravets, N., and Derkach, S. (2024). Mouthwash as a factor in controlling the formation of soft dental plaque in patients with orthodontic treatment. *Bulletin of Medical and Biological Research, 6(2),* 38-46. https://doi.org/10.61751/bmbr/2.2024.38

Kubanichbekov, M.K., Adambekov, D.A., Aldjambaeva, I.S., and Tsoi, A.R. (2021). Monitoring of antibioticresistance of some topical causative agents of pyoinflammatory diseases in the Kyrgyz Republic. *Scientific and Practical Journal Healthcare of Kyrgyzstan, 4,* 40-46. https://doi.org/10.51350/zdravkg2021124440

Kuczumow, A., Chalas, R., Nowak, J., Smulek, W., & Jarzebski, M. (2020). Novel approach to tooth chemistry: Quantifaction of human enamel apatite in context for new biomaterials and nanomaterials development. *International Journal of Molecular Science, 22*(1), 279. https://doi.org/10.3390/ijms22010279.

Mamaladze, M., Jalabadze, N., Chumburidze, T., Svanishvili, N., and Vadachkoria, D. (2022). X-ray spectral analysis of dental hard tissue trace elements (electron-microscopic examination). *Georgian Medical News, 3(324),* 204-210.

Mardiati, D. C., Alorgbey, B., & Zarogi, A. B. (2024). The relationship between educational level and the role of parents with learning achievement in mathematics. *Interval: Indonesian Journal of Mathematical Education, 2*(1), 22-28. https://doi.org/10.37251/ijome.v2i1.983.

Martins, J.N.R., Ensinas, P., Chan, F., Babayeva, N., von Zuben, M., Berti, L., (...) Ben Itzhak, J., and Versiani, M.A. (2024a). Worldwide Prevalence of Single-rooted with a Single Root Canal and

Four-rooted Configurations in Maxillary Molars: A Multi-center Cross-sectional Study with Meta-analysis. *Journal of Endodontics, 50(9),* 1254-1272. https://doi.org/10.1016/j.joen.2024.06.010

Martins, J.N.R., Ensinas, P., Chan, F., Babayeva, N., von Zuben, M., Berti, L., (...) Ben Itzhak, J., and Versiani, M.A. (2024b). Worldwide Anatomic Characteristics of the Mandibular Canine—A Multicenter Cross-Sectional Study with Meta-Analysis. *Journal of Endodontics, 50(4),* 456-471. https://doi.org/10.1016/j.joen.2024.01.016

Melisa, D., Nawahdani, A. M., & Alam, R. (2024). Meta-Analysis: Implementation of the project based learning (PjBL) model in increasing students' creative thinking in science learning. *EduFisika: Jurnal Pendidikan Fisika*, *9*(1), 88-92. https://doi.org/10.59052/edufisika.v9i1.32652.

Merdekawati, D. ., Dasuki, D., & Aguspairi, A. (2024). Validity of Blood Pressure Measurement in Hypertention Patients. *Jurnal Ilmiah Ners Indonesia*, *5*(2), 101-109. https://doi.org/10.22437/jini.v5i2.36305.

Mohamed, Y.S., Spaska, A., Andrade, G., Baraka, M.A., Ahmad, H., Steele, S., Abu-rish, E.Y., Nasor, E.M., Forsat, K., Teir, H.J., Bani, I., and Panigrahi, D. (2024). Hand hygiene knowledge, attitude, and practice before, during and post COVID-19: a cross-sectional study among university students in the United Arab Emirates. *Infection Prevention in Practice, 6(2),* 100361. https://doi.org/10.1016/j.infpip.2024.100361

Motevasselian, F., Abdi, K., Ghodarati, H., Shamshiri, A.R., Lippert, F., and Hessari, H. (2023). The role of lead and cadmium in deciduous teeth and saliva on dental caries in children residing in Tehran, Iran. *Journal of Trace Elements in Medicine and Biology*, *79,* 127209. https://doi.org/10.1016/j.jtemb.2023.127209

Nedoklan, S., Knezovic, Z., Knezovic, N., and Sutlovic, D. (2021). Nutrition and mineral content in human teeth through the centuries. *Archives of Oral Biology*, *124*, 105075. https://doi.org/10.1016/j.archoralbio.2021.105075

Ningsih, E. (2024). Increasing student learning motivation using inquiry methods in chemistry lessons. *Journal of Chemical Learning Innovation*, *1*(1), 7-13. https://doi.org/10.37251/jocli.v1i1.1017.

Noy, A.F., Zilberman, U., Regev, N., and Moskovitz, M. (2020). Drinking desalinated water that lack calcium and magnesium has no effect on mineral content of enamel and dentin in primary teeth. *Journal of Clinical Pediatric Dentistry, 44(1),* 47-51. https://doi.org/10.17796/1053-4625-44.1.8

Nurbaev, A.J., Kalybaev, S.A., Ashyralieva, A.Sh., Kulchoroeva, A.K., and Baktybekov, S.B. (2022). Epidemiologic study of complete tooth loss among the elderly and elderly population depending on the region of residence in the Kyrgyz Republic. *Bulletin of the Kyrgyz State Medical Academy named after I.K. Akhunbaev*, *3(3),* 111-115.

O'Donohue, L.S., Friedland, M.H., Shankar, P.R., Gonzalez-Cabezas, C., Flannagan, S.E., Aronovich, S., Masotti, M., Bornschein, R.E., and Davenport, M.S. (2024). Direct quantification of gadolinium retention in young patients by ICP-MS analysis of extracted teeth. *AJR. American Journal of Roentgenology, 222(6),* e2430927. https://doi.org/10.2214/ajr.24.30927

Oktavia, R., Lanita, U., Siregar, S. A., & Perdana, S. M. (2024). Efektivitas Edukasi Kesehatan Tentang Polycystic Ovary Syndrome (PCOS) Melalui Media Sosial Terhadap Pengetahuan dan Sikap Remaja Putri di Madrasah Aliyah Laboratorium Jambi. *Jurnal Kesmas Jambi*, *8*(2), 81-93. https://doi.org/10.22437/jkmj.v8i2.32755.

Oshurko, A.P., Oliinyk, I.Y., and Kuzniak, N.B. (2022). Anatomical and topographic classification of the mandibular canal with bone atrophy caused by the loss of the masticatory teeth. *Romanian Journal of Stomatology, 68(4),* 160-166. https://doi.org/10.37897/RJS.2022.4.1

Pangestu, E. (2024). Analysis of the contribution of agility and body flexibility to dribbling skills. *Multidisciplinary Journal of Tourism, Hospitality, Sport and Physical Education*, *1*(1), 6-10. https://doi.org/10.37251/jthpe.v1i1.1036.

Putri, F. E., Hubaybah, H., Lesmana, O., Putra, A. N., & Fitri, A. (2024). Pelatihan Pembuatan Kompos pada Facility Care untuk Mengurangi Jumlah Sampah Organik di Fakultas Kedokteran dan Ilmu Kesehatan Universitas Jambi. *Jurnal Salam Sehat Masyarakat (JSSM)*, *6*(01), 8-20. https://doi.org/10.22437/jssm.v6i01.37359.

Qodri, N., & Hassan, Q. M. A. (2023). Comparison of concept understanding using the scramble learning method between courselab interactive media and microsoft powerpoint media. *Tekno* -

Pedagogi : Jurnal Teknologi Pendidikan, *13*(1), 50-59. https://doi.org/10.22437/teknopedagogi.v13i1.38455.

Quzwain, F., Shafira, N. N. A., Aryanty, N. ., & Raudhoh, S. (2024). Interprofessional Learning Development In Indonesia Health Study Program. *Jambi Medical Journal : Jurnal Kedokteran Dan Kesehatan*, *12*(2), 112-117. https://doi.org/10.22437/jmj.v12i2.37316.

Ravshanov, A.X., Suhail, M., Komilova, N., and Ravshanov, S. (2024). Medical geographical zoning in part of Uzbekistan – A regional synthesis. *Regional Science Policy and Practice, 16(12),* 100142. https://doi.org/10.1016/j.rspp.2024.100142

Rini, E. F. S., Oktavia, W. D., & Hong, D. H. (2024). The relationship of motivation and physics learning outcomes using the learning cycle 5E model. *EduFisika: Jurnal Pendidikan Fisika*, *9*(1), 81-87. https://doi.org/10.59052/edufisika.v9i1.29642.

Rosa, M.J., Gennings, C., Curtin, P., Alcala, C.S., Lamadrid-Figueroa, H., Tamayo-Ortiz, M., Mercado-Garcia, A., Torres-Olascoaga, L., Téllez-Rojo, M.M., Wright, R.O., Arora, M., Austin, C., and Wright, R.J. (2024). Associations between prenatal metal and metalloid mixtures in teeth and reductions in childhood lung function. *The Science of the Total Environment*, *938,* 173352. https://doi.org/10.1016/j.scitotenv.2024.173352

Sarna-Bos, K., Skic, K., Boguta, P., Adamczuk, A., Vodanovic, M., & Chalas, R. (2023). Elemental mapping of human teeth enamel, dentine and cementum in view of their mictostructure. *Micron*, *172*, 103485. https://doi.org/10.1016/j.micron.2023.103485

Setiya Rini, E. F., Bramastia, B., Aditia, K., Fitriani, F., & Siswanto, P. (2024). Analysis of science laboratory management to support science learning: A systematic review. *Integrated Science Education Journal*, *5*(1), 49-58. https://doi.org/10.37251/isej.v5i1.799.

Setiyani, E. N., Panomram, W., & Wangdi, T. (2024). Development of predict observe explain based flat side building worksheets to improve students' mathematical representation skills. *Interval: Indonesian Journal of Mathematical Education*, *2*(1), 15-21. https://doi.org/10.37251/ijome.v2i1.984.

Sholikhah, D. U., Puspita, E., & Mardiah, A. (2024). The effect of puzzle game therapy on fine motor development in children 3-5 years in play group aisyiyah 27 surabaya. *Jurnal keperawatan universitas jambi*, *9*(1), 1-6.

Susanti, S. N., Sukarmin, S., Jauhar, M. ., Tiara, N., & Lasmini, L. (2024). Efikasi Diri, Dukungan Sosial, dan Self-Care Management Klien Hipertensi. *Jurnal Ilmiah Ners Indonesia*, *5*(2), 62-80. https://doi.org/10.22437/jini.v5i2.37546.

Taufiqurrahman, F. (2024). The Overview of Ureteral Colic in Ureterolithiasis Patients Based on the Location of Stones Observed on Urographic CT-scan. *Journal of Medical Studies*, *4*(3), 111-119. https://doi.org/10.22437/joms.v4i3.38942.

Tihtonen, K., Korhonen, P., Isojärvi, J., Ojala, R., Ashorn, U., Ashorn, P., and Tammela, O. (2022). Calcium supplementation during pregnancy and maternal and offspring bone health: A systematic review and meta-analysis. *Annals of the New York Academy of Sciences, 1509(1),* 23-36. https://doi.org/10.1111/nyas.14705

Tyas, H., & Suttiwan, W. (2023). Development of learning media for vector subject matter. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *13*(1), 60-69. https://doi.org/10.22437/teknopedagogi.v13i1.38457.

Usupbekova, T.R., Kalbaev, A.A., and Abdullaeva, K.A. (2021). The prevalence and intensity of dental caries of schoolchildren in Osh of Kyrgyz Republic. *Bulletin of the Kyrgyz State Medical Academy named after I.K. Akhunbaev, 2(2),* 80-85.

Wierichs, R.J., Mester, J., Wolf, T.G., Meyer-Lueckel, H., and Esteves-Oliveira, M. (2022). Effects of the association of high fluoride- and calcium-containing caries-preventive agents with regular or high fluoride toothpaste on enamel: An in vitro study. *Clinical Oral Investigations, 26(3),* 3167-3178. https://doi.org/10.1007/s00784-021-04299-4

Widiasta, A., Ilman, M., & Rachmadi, D. (2024). The Art of Management of Children with Steroid-Resistant and Cyclophosphamide-Resistant Nephrotic Syndrome in Indonesia. *Jambi Medical Journal : Jurnal Kedokteran Dan Kesehatan*, *12*(2), 125-131. https://doi.org/10.22437/jmj.v12i2.29348.

Widodo, R. (2024). The influence of health promotion animation videos on students' knowledge of sexual violence prevention. *Journal of Health Innovation and Environmental Education*, *1*(1), 7-13. https://doi.org/10.37251/jhiee.v1i1.1033.

Yaremchuk, N.Ih., Oshurko, A.P., and Oliinyk, I.Yu. (2023). Age assessment of the dynamics of morphological rearrangement of bone tissue of the articular processes of the human lower jaw depending on the loss of the masticatory teeth. *Polski Merkuriusz Lekarski, 51(2),* 120-127. https://doi.org/10.36740/Merkur202302103

Yepes, J.F., McCormick-Norris, J., Vinson, L.A., Eckert, G.J., Hu, H., Wu, Y., Jansen, E.C., Peterson, K.E., Tellez-Rojo, M.M., and Mier, E.A.M. (2020). Blood levels of lead and dental caries in permanent teeth. *Journal of Public Health Dentistry*, *80(4),* 297-303. https://doi.org/10.1111/jphd.12384

Younes, A., Ali, J.S., Duda, A., Alliot, C., Huclier-Markai, S., Wang, J., Kabalan, F., Nemirovsky, D., Deng, R., Nur, M.T., Cao, M., Groveman, S., Drain, C.M., and Alexandratos, S.D. (2021). Uptake and removal of uranium by and from human teeth. *Chemical Research in Toxicology*, *34(3),* 880-891. https://doi.org/10.1021/acs.chemrestox.0c00503

Zhumaev, A.Kh., and Eshpulatov, A.Zh. (2021). Peculiarities of dental status of patients of older age groups. *Online Scientific Journal of Sustainability and Leading Research*, *1(6),* 100-115.