The Efficacy of Natural Mineral Water "Kara-Shoro" in Caries Prevention in Children

Abdyrakman Eshiev[1,*], Nursultan Akunov[2], Daniyar Eshiev[1], Nurlan Azimbaev[1] and Nursultan Kurmanbekov[1]

[1]*Department of Surgical Dentistry, with a course in Pediatric Surgical Dentistry, Osh State University, 723500, 331 Lenin Str., Osh, Kyrgyz Republic*

[2]*Department of Orthopedic Dentistry with a course in Orthodontics, Osh State University, 723500, 331 Lenin Str., Osh, Kyrgyz Republic*

Abstract: *Background:* Dental caries remains one of the most prevalent oral health issues among children and adults. This study investigates the efficacy of "Kara-Shoro" mineral water as a natural source of fluoride for caries prevention in children aged 7-15. The mineral water used in the study contains 7.83 mg/L of fluoride, along with high concentrations of bicarbonates (1,680 mg/L) and chlorides (4,541 mg/L), classifying it as a bicarbonate-chloride type mineral water.

Methods: The research was conducted over three years in two villages of the Kyrgyz Republic and included educational, therapeutic, and preventive phases. In the test group, a regimen of regular "Kara-Shoro" mineral water use was implemented, both for topical application (oral rinsing) and systemic consumption. The control group followed standard caries-prevention methods, including toothbrushing without using this mineral water.

Findings: Children consuming "Kara-Shoro" mineral water exhibited a significant reduction in caries intensity, as measured by the DMFT+dmft index (number of decayed, missing, and filled permanent and deciduous teeth) and the DMFT index (same metric, limited to permanent teeth), compared to the control group. By the end of the study, three years after the initiation of preventive measures, the DMFT index was 0.52±0.18 in the test group and 3.44±0.68 in the control group. The mean caries increment in the test group was 0.46 cavities, representing 16.91% of the increment observed in the control group, which reached 2.72 ($p<0.001$). The final reduction in caries prevalence in the test group compared to the control was 83.09%. No signs of fluorosis were observed in either group.

Conclusion: As a result, the use of "Kara-Shoro" mineral water may be a promising approach to caries prevention in children, particularly in regions with low fluoride levels in drinking water. Further research is required to determine the optimal application regimen and assess long-term effects.

Keywords: Fluoride,mixed dentition caries index, index, oral hygiene, oral cavity, dentistry, public health.

INTRODUCTION

Dental caries is one of the most common oral diseases in both adults and children. It is a pathological process characterised by the destruction of tooth enamel due to organic acids produced by bacteria during carbohydrate metabolism [1]. Initially, caries manifests as enamel demineralisation, followed by the formation of a carious lesion that may deepen and reach the pulp, causing inflammation and severe pain. If left untreated, caries can lead to complications such as pulpitis, periodontitis, and even tooth loss [2-4].

According to the World Health Organization (WHO)[5], 2 billion adults have caries in permanent teeth, and 514 million children have caries in primary teeth. The prevalence of caries depends on multiple factors, including oral hygiene standards, access to dental care, dietary habits, climatic conditions, and socioeconomic status [6]. In developed countries, individuals visit dentists more frequently, benefiting from advanced technologiesand materials. Additionally, the routine use of fluoride-containing toothpaste contributes to lower caries rates compared to developing countries, where preventive dental care may be inadequate. Furthermore, regions with soft water, deficient in fluoride, exhibit higher caries prevalence than areas with naturally fluoridated water [7].

The primary cause of caries is the destruction of enamel by acids produced by bacteria during the metabolism of sugars [8]. However, other risk factors contribute to disease progression. These include genetic predisposition, congenital and acquired enamel defects, insufficient mineralisation of dental hard tissues, impaired salivary secretion (reducing oral protective functions), and gastrointestinal disorders affecting calcium and phosphorus absorption - essential for dental health [9-13]. Lifestyle factors also play a significant role: poor diet (excessive carbohydrates and mineral deficiencies), frequent consumption of acidic and sugary beverages, and inadequate oral hygiene [14-16].

*Address correspondence to this author at the Department of Surgical Dentistry, with a course in Pediatric Surgical Dentistry, Osh State University, 723500, 331 Lenin Str., Osh, Kyrgyz Republic;
E-mail: eshievabdyrakman52@gmail.com

E-ISSN: 1929-4247/25 **© 2025 Lifescience Global**

It should be noted that disturbances in the composition and quantity of saliva, alongside the influence of cariogenic bacteria, play a particularly significant role, as saliva, having an alkaline pH, fulfils a natural protective function. It not only contributes to acid neutralisation but also participates in enamel remineralisation [17]. Furthermore, studies indicate that certain systemic conditions, such as diabetes mellitus, may alter salivary composition and promote caries development [18-20].

At the same time, dental caries itself affects an individual's overall health. Chronic oral infectious foci can lead to various systemic diseases, compromising the entire organism [21]. This contributes to inflammatory disorders such as sinusitis, otitis media, and tonsillitis, as well as rheumatoid diseases. During pregnancy, oral infections may adversely affect foetal health [22]. Additionally, scientific evidence suggests a potential association between chronic oral inflammation and neurodegenerative disorders, including Alzheimer’s disease [23,24].

Beyond medical implications, caries also impacts psychological well-being[25, 26]. Pain and discomfort during mastication may reduce quality of life, leading to sleep disturbances and impaired concentration. Dental defects can cause aesthetic concerns, which in turn affect mental health and self-esteem, ultimately diminishing overall qualityof life [27]. Thus, caries is not merely a dental issue but a serious interdisciplinary problem requiring a comprehensive approach to prevention and treatment.

Despite advances in preventive measures, its prevalence - particularly among children - remains high. This is attributed to multiple factors, including individual hygiene practices, dietary habits, and access to dental care. Social determinants also play a crucial role: parental education levels, awareness of caries prevention methods, and general attitudes toward oral hygiene. Research demonstrates that in families where parents prioritise preventive dental care and instil proper oral hygiene habits in children, the risk of caries is significantly lower.

Modern caries prevention strategies primarily rely on fluoride application, which strengthens enamel and reduces the risk of tooth decay. One natural source of fluoride is the mineral water Kara-Shoro, which contains this element at optimal concentrations. Rational use of this water could serve as an effective adjunct to primary prevention measures, particularly in regions with insufficient fluoride levels in drinking water. This study aimed to experimentally evaluate the efficacy of low-dose Kara-Shoro mineral water in caries prevention among children aged 7-10 years. The investigation considered the water’s mineral composition, natural origin, ecological purity, and potential impact on children’s general health, thereby providing a more precise assessment of its therapeutic and prophylactic properties.

MATERIALS AND METHODS

A total of 60 schoolchildren aged 7-15 years attending Secondary School No. 62 in the village of Ak-Terek and Secondary School No. 32 in the town of Salamalik participated in the study. The participants were divided into two groups - an experimental group and a control group - each comprising 30 individuals. The gender distribution was balanced across both groups: 15 males and 15 females in the experimental group, and 16 males and 14 females in the control group. Selection criteria were limited to participants' age, their parents' voluntary informed consent to participate in the study, and the absence of plans to relocate within the next 3 years. Factors such as socioeconomic status and baseline dental health condition were not taken into consideration during the selection process.

The tested preventive methodology comprised three stages:

1. Educational stage: oral health sessions were conducted for both children and their parents.

2. Therapeutic stage: oral cavity sanitation, including dental restoration using contemporary materials and tooth extraction when necessary. Baseline oral hygiene indices were determined for both groups. This established a common starting point for the study, enabling an objective comparison of the outcomes of the preventive measures throughout the study period.

3. Preventive stage: Use of “Kara-Shoro” mineral water in two forms:

- topical application: Toothbrushing under parental supervision in the morning hours, with rinsing of the oral cavity using “Kara-Shoro” mineral water;

- endogenous application: Daily intake of 130 ml of mineral water at 17:00 under parental supervision.

For the control group, parents were instructed to supervise the children to prevent any consumption of the water. The water was supplied exclusively by the study's authors to maintain control over its use.

The Kara-Shoro mineral water used in the study is commercially available and was obtained from a source produced at the Ulak-Chapchu site within the Kara-Shoro Nature Park. The water underwent a thorough physicochemical examination to determine its mineral profile and ensure its safety for regulated human use. It was classified as a bicarbonate-chloride type mineral water after examination revealed high levels of fluoride (7.83 mg/L), bicarbonate (1,680 mg/L), and chloride (4,541 mg/L). This evaluation was necessary to confirm the water's ecological cleanliness and to demonstrate its suitability for restricted topical and systemic use in preventive dentistry procedures. Although it required careful dosage monitoring to prevent fluorosis, the elevated fluoride level suggested possible usefulness for preventing dental cavities. Regarding the water's taste, children in the experimental group willingly consumed Kara-Shoro water, although individual preferences varied.

The control group underwent only standard routine dental sanitation, which included general preventive measures such as regular toothbrushing without the use of mineral water. Follow-up examinations were conducted at intervals of 1, 1.5, 2, and 3 years. At these stages, assessments were conducted of changes in oral hygiene indices, caries intensity, and dental fluorosis. The same dentists supervised and monitored the children from both groups at all time points throughout the study period.

To objectively assess the effectiveness of caries prevention, two indices were used:

- dmft+DMFT index (decayed, missing, and filled teeth for both primary and permanent dentitions): This cumulative index reflects the total number of decayed, filled, and extracted primary and permanent teeth in a child or adolescent. It enables evaluation of both the current dental health status and the dynamic changes over time.
- DMFT index (decayed, missing, and filled permanent teeth): This index considers only permanent teeth and counts decayed, filled, and extracted units. It provides a more precise assessment of the dynamics in the health status of permanent dentition in children and adolescents, as the influence of naturally exfoliating primary teeth is excluded.

This study aligned with the ethical principles of research, including anonymity, confidentiality, and beneficence. Ethical approval of the study was obtained from the Research Ethics Commission of the Osh State University with No. FC-546.

RESULTS

The mineral composition of the water used in the study is presented in Table **1**.

The data in Table **1** indicate that the mineral water contains a relatively high, though not predominant, concentration of bicarbonates (1,680 mg/L), while chloride is the clearly dominant component (4,541 mg/L). Thus, it belongs to the bicarbonate-chloride group of mineral waters.

The presence of fluoride, a specific element, in "Kara-Shoro" mineral water may justify its potential use in dentistry. However, the fluoride concentration (7.83 mg/L) significantly exceeds the recommended safe

Table 1: Mineral Composition of "Kara-Shoro" Mineral Water from the Ulak-Chapchu Site

No.	Parameter	Concentration (mg/L)
1	HCO_3^-	1,680
2	CO_3^{2-}	<1
3	SO_4^{2-}	12
4	Cl^-	4,541
5	F^-	7.83
6	Total hardness (as $CaCO_3$)	986
7	Total alkalinity (mg $CaCO_3$/L)	1,378

Source: compiled by the authors.

levels for drinking water, which typically range from 0.5 to 1.5 mg/L (depending on the climatic zone), and the risk threshold for fluorosis is set above 1.5 mg/L (with prolonged consumption). Consequently, this water is unsuitable for daily drinking but may be utilised for caries prevention under controlled and limited application.

Educational Phase

The necessity of this research phase stems from the importance of establishing fundamental knowledge of dental health among children and their parents, motivating adherence to hygiene practices, and developing skills for the regular use of mineral water. This phase lays the foundation for the successful implementation of a three-year research plan testing the preventive methodology.

During the initial stage, a series of educational interventions were conducted to raise awareness among both children and parents regarding the importance of maintaining hygiene standards for dental health. The sessions included theoretical components (lectures, presentations, distribution of informational materials) as well as practical advice focused on the daily application of recommendations. Particular emphasis was placed on proper toothbrushing techniques, the selection of toothpaste and toothbrushes, the use of dental floss, and the importance of regular dental check-ups. Parents received guidance on caries prevention in young children and adolescents, including dietary control and monitoring sugar intake (sweets, carbohydrates).

The study authors conducted periodic monitoring of students' adherence to preventive measures through quarterly phone calls to parents and biannual discussions between teachers and the participating children.

Treatment Phase

Follow-up examinations in the groups to assess hygiene indices were conducted at 1, 1.5, 2, and 3 years after the study initiation. In all cases, no signs of fluorosis were observed in either group. At baseline, all children in the study sample exhibited unsatisfactory oral hygiene. Dental caries of varying severity was detected in 77.9% of participants in both the study and control groups, with an overall hygiene index exceeding 2.7. The mean hygiene index in the study group was 2.83±0.05, compared to 2.77±0.3 in the control group ($p>0.05$). The proportion of children with cariogenic dental plaque was 27.7±8.4% in the study group and 26.3±8.8% in the control group. The DMFT+dmft index before preventive measures was 3.00±0.27 in the study group and 3.32±0.44 in the control group.

A slight increase in the index was observed in both groups over the following year: in the study group, from 3.00±0.27 to 3.14±0.34, and in the control group, from 3.32±0.44 to 3.46±0.69 (Figure **1**). Thus, no significant differences were observed within the first year, and the variation in values was not statistically significant ($p>0.05$).

After 1.5 years, a minor trend emerged: in the study group, values decreased to 2.86±0.21, whereas in the control group, they increased to 3.81±0.23. Notably, the study group demonstrated significant improvement compared with baseline and the previous period. In contrast, the control group showed an increase in dental hard-tissue caries, resulting in a statistically significant difference ($p<0.05$).

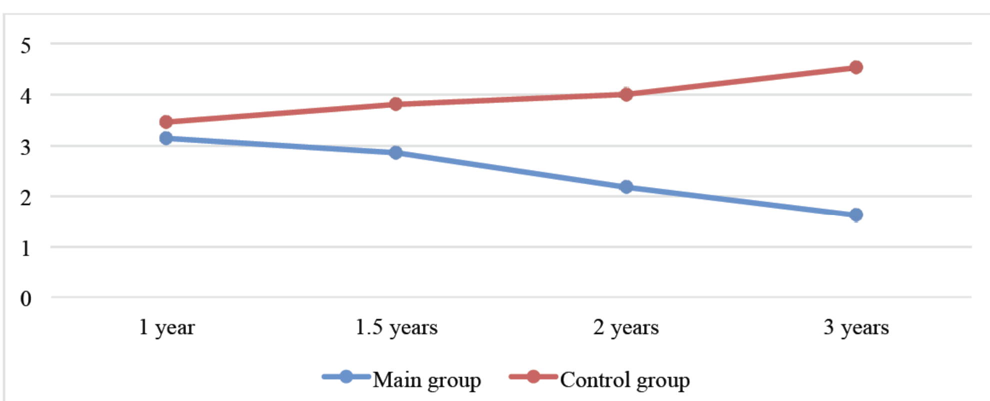

Figure 1: Changes in the mixed dentition index (DMFT+dmft) in the study and control groups over the three-year observation period.

Source: compiled by the authors.

Two years after the study initiation, the study group continued to show a decline in caries intensity (from 2.86±0.21 to 2.18±0.43), whereas the control group exhibited further progression (from 3.81±0.23 to 4.01±0.34). However, the differences remained statistically insignificant (p>0.05). By the end of the study (3 years), the indices in the study group were 1.62±0.19, compared to 4.53±0.38 in the control group, confirming a statistically significant difference (p<0.01).

During the mixed dentition phase in children and adolescents, the reduction in the mixed dentition index in the study group indicates improved oral hygiene. The eruption of permanent teeth was accompanied by a decrease in caries intensity in the study group, suggesting a reduction in caries prevalence due to preventive measures using "Kara-Shoro" mineral water. Conversely, in the control group, the emergence of permanent teeth was associated with an increase in overall caries intensity, indicating insufficient efficacy of standard preventive measures in maintaining the health of newly formed permanent teeth.

To eliminate the influence of permanent tooth eruption on the assessment of preventive measures in both groups, we also monitored changes in the DMFT index, which accounts exclusively for permanent teeth (decayed, missing, and filled teeth) and is thus independent of primary dentition status.

As shown in Figure **2**, the initial caries intensity in permanent teeth was 0.08±0.16 in the study group, compared to 0.86±0.15 in the control group. Six months after preventive interventions, the DMFT index in the study group was 0.13±0.13, versus 0.97±0.19 in the control group. The mean increase in carious lesions during this period was 0.05 in the study group and 0.11 in the control group. However, the observed difference was statistically insignificant (p>0.05).

One year after the implementation of preventive measures, the DMFT index in the leading group increased to 0.22±0.13. Compared to the previous examination, the increment was 0.02 (p>0.05), and relative to the baseline value, it was 0.03 (p>0.05). In the control group, the index increased by 0.16 (p>0.05) compared with the previous examination and by 0.20 (p>0.05) relative to baseline.

After 1.5 years of preventive intervention, the DMFT index in the leading group reached 0.33±0.15, which was 0.20 higher than the initial level. In the control group, the increase in carious lesions during this period was 0.92, demonstrating a statistically significant difference (p<0.01) compared to the leading group. At this stage, the caries reduction rate in the leading group was 71.61%.

Two years after the study began, a sustained trend was observed: in the control group, the increase in carious lesions was 2.12 (p<0.001), while in the leading group, only a minor but statistically significant increment of 0.39 from baseline was recorded (p<0.01). The final DMFT values were 0.45±0.17 in the leading group and 2.84±0.71 in the control group (p<0.001). By this stage, the caries reduction rate had reached 80.68%.

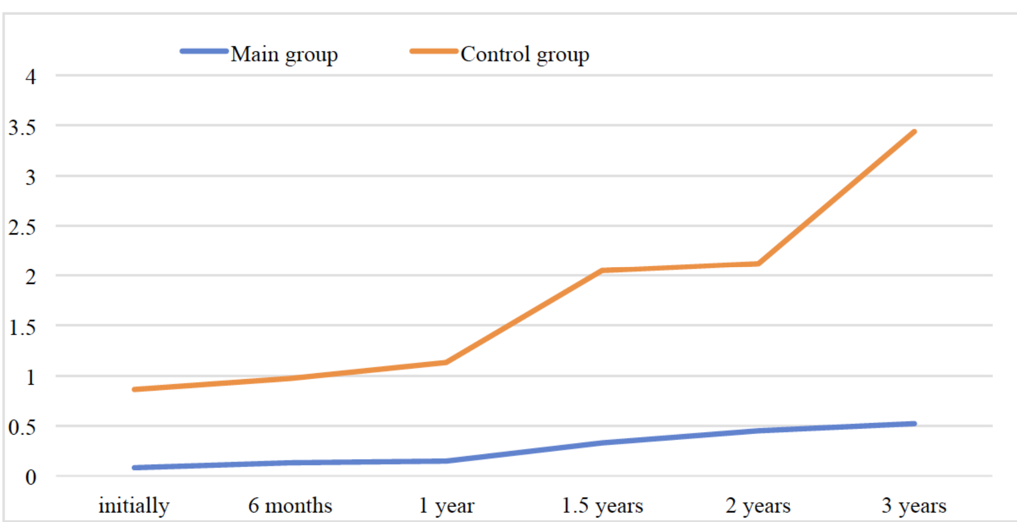

Figure 2: Changes in the caries intensity index (DMFT) of permanent teeth in the primary and control groups over a three-year observation period.

Source: compiled by the authors.

By the end of the preventive programme, the DMFT index was 0.52±0.18 in the leading group and 3.44±0.68 in the control group. The total caries increment over the entire study period in the leading group averaged 0.46 cavities, representing only 16.91% of the increment observed in the control group, which reached 2.72 cavities ($p<0.001$). The final caries reduction rate at the conclusion of the study was 83.09%.

Prospects for the Application of the Findings

The obtained results demonstrate the high potential of using “Kara-Shoro" mineral water for caries prevention and strengthening dental hard tissues in children. This method could be integrated into preventive programmes for children and adolescents, particularly in high-caries-risk regions. Implementing this approach in healthcare systems, especially in areas with limited access to dental services, could significantly reduce overall caries prevalence.

It is also essential to consider the application of this method in sanatorium-resort facilities, where comprehensive oral disease prevention could be conducted using natural mineral waters. The "Kara-Shoro” nature reserve, with its unique hydrological resources, presents an ideal setting for such interventions.

Furthermore, the study findings could serve as a basis for developing new guidelines on the use of mineral waters in therapeutic and preventive programmes for children, including their application in schools and healthcare institutions. These guidelines could eventually encompass not only caries prevention but also general health enhancement, immune system support, and maintenance of dental and bone health.

Further research could refine dosage and administration protocols and explore the effects of mineral water on adult populations. This would open new avenues for the use of natural mineral waters in comprehensive dental practice and the prevention of other diseases.

Thus, implementing the "Kara-Shoro” mineral water method could represent a significant advancement in caries prevention and dental health improvement in children, with potential long-term benefits for broader age groups. This approach could form the foundation for an effective national and public health programme aimed at improving population-wide oral health.

DISCUSSION

Analysis of scientific publications has shown that, at the international level, research on caries prevention using natural mineral water with a known fluoride content is rare or absent. The primary focus remains on artificial water fluoridation and the use of fluoride-containing products. However, as noted earlier, natural mineral waters containing fluoride are regulated in Europe: those at concentrations exceeding 1 mg/L are labelled "fluoridated". In comparison, levels above 1.5 mg/L require a warning against use by children under 7 years of age. Thus, due to their stable fluoride content, such waters can be utilised by dental practitioners for discretionary prescriptions.

The health of primary teeth directly influences that of permanent teeth, and neglecting issues may lead to serious complications later. Childhood caries is not merely a localised dental problem but a factor that can affect a child's overall development. It can negatively impact speech formation, food mastication efficiency, and, consequently, nutrient absorption. Deficiencies in vitamins and minerals resulting from poor chewing may impair a child's growth and development. Furthermore, the presence of decayed teeth can cause psychological discomfort, reducing self-confidence and diminishing quality of life [28].

One of the significant factors contributing to childhood caries is harmful dietary habits, often fostered by well-meaning adults. Excessive sugar consumption is not the sole cause of the problem [29-31]. Particular attention should be paid to so-called “bottle” (circular) caries, which develops in children under 4 years of age, especially with prolonged night-time feeding on milk or sweetened formulas. It primarily affects the cervical regions of the upper incisors, canines, and, less frequently, molars. The disease progresses rapidly: from the first signs to complete tooth destruction, only a few months may elapse. Treatment of bottle caries is essential and must be conducted under the supervision of a paediatric dentist, as premature loss of incisors and molars may disrupt proper occlusion and speech development [32, 33].

Caries in children progresses faster than in adults, potentially leading to premature loss of primary teeth, which can impact maxillofacial development, proper occlusal alignment, and speech [28]. Beyond physiological consequences, dental issues in childhood may instill a fear of dental treatment, influencing the child's attitude towards oral care in adulthood. This underscores the critical role of prevention: timely dental examinations, education on proper oral hygiene, and a balanced diet can help prevent severe complications and maintain long-term dental health [34]. In 2014, a national programme to prevent dental diseases in children and school students was proposed in the Kyrgyz Republic [35].

The first studies establishing a link between fluoride levels in drinking water and reduced caries prevalence were conducted in the 1930s [36]. To date, fluoride use remains the most effective method of caries prevention [37]. This trace element strengthens tooth enamel, enhancing its resistance to acids produced by bacteria. Fluorides can be administered both systemically and topically - via drinking water, toothpaste, and specialised preparations. Currently, an estimated 380 million people regularly consume artificially fluoridated water, and an additional 50 million consume drinking water with naturally optimal fluoride concentrations [38].

Fluoride is effective in caries prevention due to its multifaceted action on tooth enamel and cariogenic microorganisms. Its protective mechanism is based on several key processes. Present in saliva and dental plaque, fluoride inhibits enamel demineralisation, reinforcing its structure, while also promoting the remineralisation of early lesions. This means the enamel repair process outweighs destructive processes, reducing caries risk. Remineralisation is regarded as one of the most critical factors in combating this disease. Moreover, fluoride suppresses glycolysis - the process by which cariogenic bacteria metabolise sugars to produce enamel-eroding acids. At high concentrations, it exhibits bactericidal effects, inhibiting the growth of cariogenic bacteria and other microorganisms contributing to oral diseases. Studies demonstrate that fluoride intake during tooth formation enhances their resistance to caries later in life [39].

According to the standards established by the US Department of Health and Human Services Federal Panel on Community Water Fluoridation [39], drinking water is considered safe when fluoride concentrations range from 0.7 to 1.2 mg/L, whether naturally occurring or artificially added. This level of fluoride contributes to a significant reduction in dental caries prevalence. However, maintaining a proper balance is essential, as excessive fluoride intake can lead to adverse effects, including dental fluorosis and skeletal fluoride accumulation. In regions where the natural fluoride concentration exceeds 2 mg/L, children under 8 years old are at increased risk of developing fluorosis - a condition characterised by discolouration and reduced mineralisation of tooth enamel. Excessive fluoride intake, particularly during the early stages of enamel formation, may lead to irreversible pathological changes in enamel structure.

In areas with naturally elevated fluoride levels exceeding 2 mg/L, children younger than 8 years are at heightened risk of fluorosis. This risk is especially pronounced among children under 5, whose dental enamel is still in the formative stage [40]. In such regions, regulating fluoride concentrations in drinking water can be challenging, necessitating additional protective measures against fluoride overexposure. In communities where fluoride concentrations in drinking water surpass 4 mg/L, skeletal fluoride accumulation has been associated with an increased incidence of bone fractures, underscoring the importance of systematic monitoring of fluoride levels in potable water and other natural sources [41].

Research into the correlation between fluoride concentrations in drinking water and dental health began in 1901, when dentist F.S. McKay initiated studies in Colorado Springs, USA. In collaboration with Black [42], McKay investigated unusual tooth stains among residents, particularly children. These stains, referred to as the "Colorado Brown Stain", were found to be associated with remarkable resistance to dental caries. Subsequent investigations, involving chemist Churchill [43], identified elevated fluoride concentrations in the local water supply as the cause of enamel discolouration and increased caries resistance. This discovery led to extensive research, spearheaded in the 1930s and 1940s by Dr. H. Trendley Dean of the US National Institutes of Health. These studies conclusively demonstrated that low fluoride concentrations (0.7-1.2 mg/L) are effective in preventing dental caries without causing significant fluorosis.

The first large-scale clinical trial on water fluoridation was conducted in the 1940s in Grand Rapids, Michigan (USA), as part of the so-called Grand Rapids Fluoridation Study. This study involved adding sodium fluoride to the municipal water supply to achieve optimal fluoride levels and demonstrated a significant reduction in dental caries among tens of thousands of participants [44]. Similar studies conducted in other American cities and globally, along with subsequent 10-15-year follow-up observations, confirmed the sustained caries-preventive effects of water fluoridation. The period from the 1960s to the 1980s marked a peak in international research and implementation of water and food fluoridation. By the 1990s, research intensity diminished, as the efficacy of fluoridation had been firmly established and widely adopted [45]. Scientific attention shifted to fluoride safety, fluorosis assessment, and the determination of optimal fluoride dosages. Between 2000 and 2020, several large-scale meta-analyses - such as those in the Cochrane Review Database - confirmed the effectiveness of water fluoridation but also raised concerns about the need for individualised fluoride dose control from drinking water, toothpaste, and dietary sources [46].

Contemporary research focuses on the prevalence of dental caries and the associated risk factors among children in low- and middle-income countries. Among the most significant contributing factors are unrestricted sugar consumption, lack of oral hygiene education, and the absence or inefficacy of national fluoride programmes [47-49]. In Kyrgyzstan, contrary to global trends, dental caries incidence continues to rise. As noted by Akunov [50], caries prevalence among various age groups may reach 98.2%. Furthermore, a recent study by Eshiev [51], which addressed inflammatory diseases of the maxillofacial region in children, found that out of 959 paediatric patients, 96.9% had teeth destroyed by caries. These findings are consistent with national data reported by Eshiev, which indicate a caries prevalence of 94.7% among 12-year-old children. Other studies report primary tooth caries rates of 90.0% and higher among children nationwide, with prevalence among 12-year-olds ranging from 72.0% to 77.0% [52]. For comparison, a recent study conducted in Mexico City found that only 50% of schoolchildren aged 6 to 12 years had dental caries [53]. These findings highlight the critical importance and urgency of addressing the caries epidemic in Kyrgyzstan.

European legislation regarding the labelling of natural mineral waters stipulates that those waters containing more than 1.5 mg/L of fluoride must carry a warning label: “Contains more than 1.5 mg/L of fluoride: not suitable for regular consumption by infants and children under 7 years of age”. Additionally, it is mandated that waters with fluoride concentrations exceeding 1 mg/L be labelled as “fluoridated”. As a result, natural mineral water has become a convenient fluoride source with known and stable concentrations over time [47].

The Kara-Shoro Nature Park is located in the mountainous region of Kyrgyzstan and represents an ecosystem with a high degree of ecological preservation, characterised by rich biodiversity and unique hydrological resources. The park's territory encompasses numerous mineral water springs, formed by the infiltration of atmospheric precipitation and groundwater through layers of mountain rock. This filtration process enriches the water with various macro- and microelements, such as calcium, magnesium, and fluoride, which are essential for maintaining human health.

Experimental studies conducted in rats have demonstrated that Kara-Shoro mineral water exhibits protective properties against various pathogenic influences, including toxic damage, and is safe for use in the treatment of urolithiasis. These findings formed the basis for developing a methodology for human treatment. In the present study, the mineral composition of this water was examined in detail. The high concentration of fluoride ions, along with other minerals, attracted the attention of researchers, as these elements may play a significant role in strengthening the hard tissues of the teeth and overall bone health.

The results of the conducted study reveal significant differences in the dynamics of dental caries between the experimental and control groups. The use of Kara-Shoro mineral water not only improved oral hygiene but also significantly reduced caries incidence in both deciduous and permanent dentition. This is confirmed by statistically significant differences between the groups, particularly at later stages of observation, when the applied method began to exert a more pronounced effect on children's dental health. Notably, in the experimental group, a deceleration in the progression of carious lesions was observed, indicating the potential long-term effectiveness of caries prevention using fluoride-containing mineral water.

Furthermore, the study's findings confirm that the use of mineral water is a safe preventive measure, as no signs of fluorosis were observed despite the water's high fluoride content. This is of considerable importance, as the presence of fluoride in drinking water can raise concerns about potential adverse effects associated with excess intake, especially with prolonged use. However, the research has demonstrated that, under controlled and moderate application - as practised in this study - fluoride does not pose a risk to dental health. This outcome aligns with international evidence, which shows that moderate fluoride use reduces caries rates without jeopardising dental health, provided proper control and dosing are maintained.

The trend towards reduced caries incidence in the experimental group following the use of mineral water indicates that fluoride-based preventive strategies may be effective in the long term.

However, it is essential to consider that the outcomes of such interventions may be influenced by additional factors, such as diet, genetic predisposition, general health status, and adherence to hygiene practices, which should be taken into account in further research and in the implementation of this method in broader clinical practice.

CONCLUSIONS

The conducted study confirmed that both topical and endogenous application of Kara-Shoro mineral water significantly contribute to the reduction of dental caries intensity among children aged 7-15 years (the age of participants at the onset of the study). After a 3-year observation period, the DMFT (Decayed, Missing, and Filled Teeth) index in the experimental group was 6.6 times lower than in the control group, indicating the high efficacy of the proposed preventive method. In the control group, which received standard oral hygiene care, a significant increase in the number of carious lesions was observed. In contrast, in the experimental group, a deceleration in their progression was noted. These results constitute compelling evidence that the use of Kara-Shoro mineral water substantially reduces the risk of caries development, as supported by statistical data.

Despite the high fluoride content in the water, no signs of dental fluorosis were detected in children with limited, controlled use, confirming the safety of the proposed approach. This finding underscores the need for further investigation into optimal fluoride dosage and exposure duration to ensure its effective utilisation without compromising health.

The results are consistent with global scientific data indicating that the initial introduction of fluorides into a population reduces caries incidence among younger cohorts, with noticeable effects emerging within 2 years. This is corroborated by numerous studies demonstrating the beneficial impact of fluoride on caries reduction in countries where such preventive programmes are widely implemented. Furthermore, growing evidence suggests that these strategies contribute to a decline in caries rates not only in children but also in adults.

Global experience has shown that dental fluorosis may complicate effective fluoride-based caries prevention - an alteration in the appearance of tooth enamel caused by subsurface porosity resulting from hypoplasia or hypomineralisation. These changes occur due to prolonged fluoride exposure during tooth development. Therefore, it is imperative to ensure meticulous monitoring of fluoride's effects to prevent adverse outcomes and guarantee the highest possible safety standards for children's health.

It should be noted that fluorosis is not the sole type of enamel defect; various other factors unrelated to fluoride can also cause enamel alterations. The identification and diagnosis of fluorosis and other enamel pathologies require regular examinations by dental professionals and oral health specialists to adjust fluoride levels and other environmental influences promptly.

A limitation of the study is that typical confounding factors such as diet, nutritional habits, intake of multivitamins and microelements, and prior tooth fluoridation were not systematically analysed or controlled for, which may have influenced the outcomes. Additionally, despite efforts to control for exposure, the possibility of children in the control group unintentionally consuming Kara-Shoro mineral water cannot be entirely excluded.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available on request from the corresponding author.

FUNDING

No funding was received for the writing of the present paper.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

This study aligned with the ethical principles of research, including anonymity, confidentiality, and beneficence. Ethical approval of the study was obtained from the Research Ethics Commission of the Osh State University with No. FC-546. Parents of the participants were informed about the study and provided their consent.

CONFLICTS OF INTEREST

The authors have no relevant financial or non-financial interests to disclose.

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] Borisenko AV. Dental Caries. Kyiv: Book Plus; 2005.

[2] Donnermeyer D, Dammaschke T, Lipski M, Schäfer E. Effectiveness of diagnosing pulpitis: a systematic review. Int Endod J 2023; 56: 296-325. https://doi.org/10.1111/iej.13762

[3] Van Dyke TE, Dave S. Risk factors for periodontitis. J Int Acad Periodontol 2005; 7: 3-7.

[4] Taylor GW, Manz MC, Borgnakke WS. Diabetes, periodontal diseases, dental caries, and tooth loss: a review of the literature. Compend Contin Educ Dent 2004; 25: 179-84.

[5] World Health Organization. Global Oral Health Status Report: Towards Universal Health Coverage for Oral Health by 2030. Geneva: WHO; 2022. Available from: https://www.who.int/publications/i/item/9789240061484

[6] Babayeva NN. The modern aspects of the professional hygiene of the mouth cavity: plaque removing in smokers. Azerbaijan Med J 2010; 2: 141-2.

[7] Marthaler TM. Changes in dental caries 1953-2003. Caries Res 2004; 38: 173-81. https://doi.org/10.1159/000077752

[8] Strużycka I. The oral microbiome in dental caries. Pol J Microbiol 2014; 63: 127-35. https://doi.org/10.33073/pjm-2014-018

[9] Opal S, Garg S, Jain J, Walia I. Genetic factors affecting dental caries risk. Aust Dent J 2015; 60: 2-11. https://doi.org/10.1111/adj.12262

[10] Vargas-Ferreira F, Salas MMS, Nascimento GG, Tarquinio SBC, Faggion CM, Peres MA, et al. Association between developmental defects of enamel and dental caries: a systematic review and meta-analysis. J Dent 2015; 43: 619-28. https://doi.org/10.1016/j.jdent 2015.03.011

[11] Pretty IA, Ellwood RP. The caries continuum: opportunities to detect, treat and monitor the re-mineralization of early caries lesions. J Dent 2013; 41: S12-21. https://doi.org/10.1016/j.jdent 2010.04.003

[12] dos Santos Letieri A, Siqueira WL, Solon-de-Mello M, Masterson D, Freitas-Fernandes LB, Valente AP, et al. A critical review on the association of hyposalivation and dental caries in children and adolescents. Arch Oral Biol 2022; 144: 105545. https://doi.org/10.1016/j.archoralbio 2022.105545

[13] Jajam M, Bozzolo P, Niklander S. Oral manifestations of gastrointestinal disorders. J Clin Exp Dent 2017; 9: e1242-8. https://doi.org/10.4317/jced.54008

[14] Harris R, Nicoll AD, Adair PM, Pine CM. Risk factors for dental caries in young children: a systematic review of the literature. Community Dent Health 2004; 21: 71-85.

[15] Pashova S, Radev R, Dimitrov G. Physical properties of edible films with different composition. Qual Access Success 2019; 20(171): 152-6. Available from: https://www.researchgate.net/profile/Sabka-Pashova/publication/335291586_FOOD_SAFETY_MANAGEMENT/links/630f0146acd814437fee0343/FOOD-SAFETY-MANAGEMENT.pdf

[16] Pashova S, Radev R. Labeling of fresh fruits and vegetables. Qual Access Success 2021; 22(181): 148-52. Available from: https://www.researchgate.net/publication/350515216_Labeling_of_Fresh_Fruits_and_Vegetables

[17] Bilyschuk L, Keniuk A, Goncharuk-Khomyn M, Yavuz I. Association between saliva quantity and content parameters with caries intensity levels: a cross-sectional study among subcarpathian children. Braz Res Pediatr Dent Integr Clin 2019; 19: e5048. https://doi.org/10.4034/PBOCI 2019.191.121

[18] Coelho AS, Amaro IF, Caramelo F, Paula A, Marto CM, Ferreira MM, et al. Dental caries, diabetes mellitus, metabolic control and diabetes duration: a systematic review and meta-analysis. J EsthetRestor Dent 2020; 32: 291-309. https://doi.org/10.1111/jerd.12562

[19] de Sanctis V, Soliman A, Tzoulis P, Daar S, Kattamis A, Delaporta P, et al. The use of oral glucose-lowering agents (GLAs) in β-thalassemia patients with diabetes: preliminary data from a retrospective study of ICET-A Network. Acta Biomed 2022; 93(2): e2022162.

[20] Lewandowski K, Rydzewska G, Ledwoń TK. Preparation for endoscopic examinations in patients with diabetes and hypoglycaemia. Przegl Gastroenterol 2021; 16(4): 297-305. https://doi.org/10.5114/pg 2021.111763

[21] Sabharwal A, Stellrecht E, Scannapieco FA. Associations between dental caries and systemic diseases: a scoping review. BMC Oral Health 2021; 21: 472. https://doi.org/10.1186/s12903-021-01803-w

[22] Lunardelli AN, Peres MA. Is there an association between periodontal disease, prematurity and low birth weight? A population-based study. J Clin Periodontol 2005; 32: 938-46. https://doi.org/10.1111/j.1600-051X 2005.00759.x

[23] Ellefsen B, Holm-Pedersen P, Morse DE, Schroll M, Andersen BB, Waldemar G. Caries prevalence in older persons with and without dementia. J Am Geriatr Soc 2008; 56: 59-67. https://doi.org/10.1111/j.1532-5415 2007.01495.x

[24] Lhoeste-Charris Á, González CÁ, Santander MO, Sierra BS, Delbono LC, Vivas-Domínguez M. Sleep disturbances and their relation to dementia in Alzheimer's disease: a systematic review according to the PRISMA Statement. Gac Med Caracas 2025; 133: S326-37. https://doi.org/10.47307/GMC 2025.133.s1.28

[25] Dinca EB, Balseanu AT. Need to take heart? Talk to your psychiatrist for 20 minutes. J NervMent Dis 2024; 212(5): 251-4. https://doi.org/10.1097/NMD.0000000000001758

[26] Ayyachamy S, Kumar YP, Martín AC. Spherical k-means clustering in the cisplatin resistome of oral cancer. Gac Med Caracas 2025; 133(2): 459-63. https://doi.org/10.47307/GMC 2025.133.2.17

[27] Boitsaniuk SI, OstrovskyiPYu, BilykYa, Chorniy SV. Prevention of teeth caries through fissure sealing. Bull Med Biol Res 2022; 4(4): 47-51.

[28] Granville-Garcia AF, Gomes MC, Perazzo MF, Martins CC, Abreu MHNG, Paiva SM. Impact of caries severity/activity and psychological aspects of caregivers on oral health-related quality of life among 5-year-old children. Caries Res 2018; 52: 570-9. https://doi.org/10.1159/000488210

[29] Bogoyavlenskiy A, Alexyuk M, Alexyuk P, Amanbayeva M, Anarkulova E, Imangazy A, et al. Metagenomic exploration of koumiss from Kazakhstan. Microbiol ResourAnnounc 2022; 11(1): e01082-21. https://doi.org/10.1128/mra.01082-21

[30] Meier M, Summers BJ, Buhlmann U. Which symptoms bridge symptoms of depression and symptoms of eating disorders?: a network analysis. J NervMent Dis 2024; 212(1): 61-7. https://doi.org/10.1097/NMD.0000000000001715

[31] Smanalieva J. Innovations in food production. Bull Kyrg Natl Agrar Univ 2025; 23(2): 73-83. https://doi.org/10.63621/bknau./2 2025.73

[32] Dovramadjiev T, Pavlova D, Filchev R, Dimova R, Dimov D, Kavaldzhieva K, et al. Technological and human approach in complete restoration of the dental teeth jaws with

biocompatible materials. Lect Notes Netw Syst 2023; 645: 497-506.
https://doi.org/10.1007/978-981-99-0769-4_43

[33] Logvynenko I, Bursova V. Inferior alveolar nerve injury after sagittal split osteotomy of the mandible: a literature review. Chin J PlastReconstr Surg 2024; 6(4): 219-27.
https://doi.org/10.1016/j.cjprs 2024.11.001

[34] Mathur VP, Dhillon JK. Dental caries: a disease which needs attention. Indian J Pediatr 2018; 85: 202-6.
https://doi.org/10.1007/s12098-017-2381-6

[35] Cholokova GS. Clinical and Epidemiological Substantiation of the National Program for the Prevention of Dental Diseases in Children and Schoolchildren in the Kyrgyz Republic. Bishkek: Kyrgyz State Medical Institute of Retraining and Advanced Training 2014.

[36] O'Mullane DM, Baez RJ, Jones S, Lennon MA, Petersen PE, Rugg-Gunn AJ, et al. Fluoride and oral health. Community Dent Health 2016; 33: 69-99.

[37] Carey CM. Focus on fluorides: update on the use of fluoride for the prevention of dental caries. J Evid Based Dent Pract 2014; 14: 95-102.
https://doi.org/10.1016/j.jebdp 2014.02.004

[38] Water Research Commission. Fluoride in Drinking Water: Investigating the Effects of Fluoride in Drinking Water on Human Health and Nutrition in the Northern Cape. Pretoria: WRC 2009.

[39] US Department of Health and Human Services Federal Panel on Community Water Fluoridation. US Public Health Service recommendation for fluoride concentration in drinking water for the prevention of dental caries. Public Health Rep 2015; 130: 318-31.
https://doi.org/10.1177/003335491513000408

[40] Jullien S. Prophylaxis of caries with fluoride for children under five years. BMC Pediatr 2021; 21: 351.
https://doi.org/10.1186/s12887-021-02702-3

[41] Riggs BL, Hodgson SF, O'Fallon WM, Chao EYS, Wahner HW, Muhs JM, Cedel SL, Melon LJ. Effect of fluoride treatment on the fracture rate in postmenopausal women with osteoporosis. N Engl J Med 1990; 322: 802-9.
https://doi.org/10.1056/NEJM199003223221203

[42] Black GV, McKay FS. Mottled teeth—an endemic developmental imperfection of the teeth heretofore unknown in the literature of dentistry. Dent Cosmos.1916; 58: 129-56.

[43] Churchill HV. Occurrence of fluorides in some waters of the United States. Ind Eng Chem 1931; 23: 996-8.
https://doi.org/10.1021/ie50261a007

[44] Ripa LW. A half-century of community water fluoridation in the United States: review and commentary. J Public Health Dent 1993; 53: 17-44.
https://doi.org/10.1111/j.1752-7325.1993.tb02666.x

[45] Rugg-Gunn AJ, Do L. Effectiveness of water fluoridation in caries prevention. Community Dent Oral Epidemiol 2012; 40: 55-64.
https://doi.org/10.1111/j.1600-0528 2012.00721.x

[46] Urquhart O, Tampi MP, Pilcher L, Slayton RL, Araujo MWB, Fontana M, Guzmán-Armstrong S, Nascimento MM, Nový BB, Tinanoff N, Weyant RJ, Wolff MS, Young DA, Zero DT, Brignardello-Petersen R, Banfield L, Parikh A, Joshi G, Carrasco-Labra A. Nonrestorative treatments for caries: systematic review and network meta-analysis. J Dent Res 2019; 98: 14-26.
https://doi.org/10.1177/0022034518800014

[47] Yousaf M, Aslam T, Saeed S, Sarfraz A, Sarfraz Z, Cherrez-Ojeda I. Individual, family, and socioeconomic contributors to dental caries in children from low- and middle-income countries. Int J Environ Res Public Health 2022; 19: 7114.
https://doi.org/10.3390/ijerph19127114

[48] Kizatova MY, Medvedkov YB, Shevtsov AA, Drannikov AV, Tlevlessova DA. Experimental-statistical analysis and multifactorial process optimization of the crust from melon pulp separation process. J Eng Appl Sci 2017; 12(7): 1762-71.

[49] Tlevlessova D, Medvedkov Y, Kairbayeva A, Nazymbekova A. Mechanisation of the primary processing of watermelons without destroying the rind. Food Sci Technol (Campinas) 2023; 43: e86622.
https://doi.org/10.1590/fst.86622

[50] Akunov N. The etiological aspects of dental caries and the influence of fluorides on their prevalence. Bull Osh State Univ 2024; 2: 12-20.
https://doi.org/10.52754/16948610_2024_2_2

[51] Eshiev A. Prevention and treatment of inflammatory diseases of the maxillofacial region in children. Bull Osh State Univ 2022; 3: 44-51.
https://doi.org/10.52754/16947452_2022_3_44

[52] Cholokova GS, KamchybekovaASh. Epidemiology of dental caries and periodontal diseases in children in the CIS countries (review). Eurasian J Health 2019; 4: 104-16.

[53] Villalobos-Rodelo JJ, Mendoza-Rodríguez M, Islas-Zarazúa R, Márquez-Rodríguez S, Mora-Acosta M, Pontigo-Loyola AP, De Lourdes Márquez-Corona M, Medina-Solís CE, Maupomé G. Experience and prevalence of dental caries in 6- to 12-year-old school children in an agricultural community: a cross-sectional study. Children (Basel) 2021; 8: 99.
https://doi.org/10.3390/children8020099