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Dental health among adolescents in Kosovo, investigating risk factors and prevalence trends

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ABSTRACT

Dental caries remains a critical public health issue among children in Kosovo, caused by a complex interplay of dietary habits that contribute to the deterioration of oral health. This study aimed to evaluate the prevalence of dental caries in adolescents aged 12 to 16 years and to identify associated risk factors. A cross-sectional study design was employed, involving 120 students from elementary schools in the Suhareka municipality, who underwent clinical oral examinations and completed self-administered questionnaires between January and June 2023. The caries prevalence was quantified using the decayed, missing, and filled teeth (DMFT) index. Statistical analysis, performed using SPSS 26.0, demonstrated a significant association between dietary behaviors and caries incidence, with higher consumption rates correlating with increased DMFT scores. ANOVA and Fisher's post hoc tests were utilized to assess variables impacting caries progression, while the Chi-square test of independence was applied for intergroup comparisons. The status of permanent dentition was systematically evaluated through the DMFT index, with results interpreted within a 95% confidence interval. Both intrinsic and extrinsic factors affecting enamel resilience were explored, with an emphasis on developing targeted strategies to prevent dental deterioration and enhance oral health among adolescents. The outcomes of this study offer valuable insights for improving pediatric oral health in Kosovo and provide evidence-based recommendations for policymakers and healthcare professionals to formulate effective preventive strategies and public health interventions in similar demographic contexts.

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1. INTRODUCTION

Food is the most nutritional important factor in the appearance of dental caries and tooth erosion. One of the main ingredients in food is acids, natural or added which can be separated by origin into intrinsic and extrinsic factors. These are estimated to be crucial causes of tooth erosion. Low pH of acidic foods and drinks plays a significant role in the development of tooth erosion. Poor oral hygiene and continuous consumption of soft drinks lead to tooth disease [1]. In other cases that have been studied, slowly progressed caries may suddenly become rampant. Frequent exposure to erosive acids may lead to dental caries. Erosion, which is a growing problem in society, is also related to the consumption of food that is acidic as well as to the consumption of soft drinks, and it also has to do with the lifestyle and ways of feeding people [2]. The

consumption of non-alcoholic soft drinks is always increasing all over the world, specifically among the young generation, and this trend leads to early tooth loss and this issue is considered to be a serious problem. Therefore, current research is being done to discover the exact causes of this problem and at the same time to prevent those influencing factors [3]. Consumption of these beverages is increasing and this is coming most of it through the commercials and their refreshing taste, these beverages are presented as sources of vitamins, and energy boosters. The ingredients of these drinks are sugar, phosphoric acid, fructose syrup, malic acid as well as citric acid [4]. One of the most common dangers of dental decay is the intake of carbonated drinks, especially in children and adolescents. Parameters like low pH and high content of carbohydrates in soft drinks are the reasons for dental erosion and periodontal problems [5]. External factors such as soft drinks change tooth enamel, at the same time internal factors, such as eating disorders, and gastric reflux, can lead to the release of gastric acid into the mouth and this can cause loss of tooth substance or tooth erosion [6]. From available literature and researchers, explained to us that many factors affect tooth enamel, since it is exposure to soft drinks including pH, buffer capacities, acidic species, exposure time, lifestyle carbohydrate intake, and calcium and phosphate content [7]. If it is not taken in a controlled amount, erosion of the enamel causes hypersensitivity of the dentine, and as a result, pain appears [8]. The use of soft drinks causes a decrease in the pH of saliva. Known as "critical pH" for enamel dissolution is considered a pH of 5.5, while for dentin it is 6.8. The erosive potential of drinks is represented by their Ph and buffering capacity [4], [6]. Initial pH values and their buffer capacities have been determined in previously published research. The lowest pH indicated to be for carbonated drinks more than fruit juices also. Buffer capacities are ranked: fruit juices>fruit-based carbonated drinks>non-fruit-based carbonated drinks. Total acidity is made from different types of acids found or added in soft drinks like citric acid, carbonic acid, and phosphoric acid, which make oral pH low and making it harmful [9]. Significant enamel erosion was caused by beverages with low pH and no presence of fluoride. Fluoride can play a protective role in enamel erosion. The lowest pH indicated to be for carbonated drinks more than fruit juices also. The buffering capacities are in the following order: fruit juices>fruit-based carbonated drinks>non-fruit-based carbonated drinks [10]. Some of the research didn't show any significant differences between energy drinks, carbonated drinks, and fruit juices in terms of pH, but energy drinks had the highest erosive potential since they had the highest buffering capacities [11]. Many researchers have been following information on certain types of foods and beverages with a high level of acidity, such as carbonated drinks, fruit, fruit juices, and other beverages, also the timing of consumption, during main meals or snacks [12]. Soft drinks are largely produced as acidic beverages with an interval of pH between 2.5–4.0 and are consumed worldwide. The first carbonated drinks were produced in the second half of the nineteenth century. Soft drinks are made of different components in different tastes but in general, they are water as the main component, sugar or sweetener, fruit juices not from concentrate (NFC) or concentrated juices, and many other food additives are added which are expressed with E-numbers like acidifier most common acid citric E330, flavoring, carbon dioxide, coloring agents like caramel color E150 (a, b, c, d) chemical preservatives (within the legal limits), antioxidants like ascorbic acid E300, and foaming agents [13]. Sugar and fermentable carbohydrates can provide a substrate for oral bacteria action in this way it lowers the plaque and salivary pH, and as a result of all this, we have the beginning of tooth demineralization. There is a direct link between the consumption of sugars and dental caries and this has been proven by scientific research [14].

2. METHOD

The aim of this study is to analyze the impact of consuming carbonated beverages and acidic foods on the development of dental caries and tooth erosion among adolescents. The study seeks to identify the factors contributing to enamel degradation, including pH, buffering capacity, and sugar content of various commercially available drinks. Special emphasis is placed on evaluating both intrinsic and extrinsic factors influencing enamel behavior, to identify effective strategies for preventing dental damage and improving oral health in young populations. A total of 80 soft drinks were bought from the shops in Kosovo, categorized as SSB, soft drinks, fruit juices, 100% fruit juices, and assessed for pH, °Brix, and buffer capacity.

2.1. Determination of pH, °Brix, and buffer capacity

A calibrated HANNA edge® pH meter is used to measure the pH of each drink but first had been standardized with a buffer solution of pH 4.0. Samples have been tested immediately after opening at 25 °C in triplicate to give an average measurement of each drink. Then we determined the erosive potential based on the relative erosivity areas of the drinks from the apatite solubility studies in acid. "Refractometer 30PX", produced by METTLER TOLEDO was used for the determination of °Brix, at a temperature around 20 °C, measurements were repeated in triplicate for all drinks, and the average value was taken with standard deviation. Brix is the most widely used unit in the food and beverage industry. It indicates the number of dissolved solids in a liquid measured via its specific gravity (SG) [15]. One degree °Brix is 1 g of sucrose in

100 g of solution (1 °Brix=1% sugar) [16]. To measure the buffer capacity of each drink we titrated up to pH 5.5 and 7.0 from 100 mL of the samples, it seems that 1M NaOH was used as a titrant, they were carefully quenched with 0.2 mL of the titrant by mixing the sample continuously to obtain the result as accurate as possible. Titration is repeated three times in a row for all the drinks, then the average value was collected to check for accuracy and to obtain the mean value for that drink.

2.2. Participants and oral examination procedure

The second part and most important of our study represents a cross-sectional study of knowledge and practice (KP) involving 120 students. The participants for the study were recruited from two elementary schools in the municipality of Suhareka, Kosovo. The recruitment involved students aged 12 to 16 years who were asked to participate in oral clinical examinations and to complete self-administered questionnaires. The study was conducted between January and June 2023. The sample size was found using a sample size calculator with a confidence level of 95%, an error margin of 5%, and including the dropouts the requested sample size was determined to be 120. Questionnaires and help were given to the participants. The informed consent was given to the adolescents at home to analyze with their parents, within the two days, and after they reviewed it was signed by both the adolescents and their parents/guardians. After informed consent, filling out questionnaire procedures are done by a single operator to avoid interoperate bias. The questionnaire was designed based on a review of existing literature related to oral hygiene practices and dietary habits. It was structured to include demographic data, oral hygiene behaviors, dietary habits, and knowledge about oral health [17]. A detailed oral examination was carried out after answer sheets were collected. The dental examination was done in 2023 by different doctors, blinded regarding the decayed, missing, and filled teeth (DMFT) index. This research was confined to the participants between 12-16 years old. During the clinical examination, participants are seated in an ordinary chair with a supply of adequate daylight, supplemented with a torch if required to facilitate the examination [18]. Detection of dental caries was done following WHO criteria and data was recorded on a WHO oral health assessment form [19]. The examination was conducted in the morning to eliminate any errors that may occur in the evening, due to less sunlight and different food that could be eaten during the day. Between 35 to 40 adolescents were examined during the day and also the questionnaire was fulfilled. The next day 20 participants were chosen randomly and re-examined and the results were the same as the previous day, this was done to eliminate any confounding factors. Detection of dental caries was done tooth by tooth, according to DMFT and decayed, missing, filled permanent teeth or surfaces (DMFS) [20]. An oral examination has been done under the WHO criteria [7]. Inclusion and exclusion criteria ensure that the participants fit the research's target demographic and that external factors are minimized to ensure the reliability of the study findings.

2.2.1. Inclusion criteria

This study has inclusion criteria, namely; i) Age range: participants must be adolescents between the ages of 12 to 16 years old. ii) Student status: only students from the selected population who are available and willing to participate. iii) Informed consent: both the adolescent and their parents/guardians must sign an informed consent form after reviewing and understanding the examination procedure. iv) Availability for re-examination: participants must be willing to attend both the initial examination and, if chosen, the random re-examination. v) Health status: participants must be in general good health with no known medical conditions that could interfere with oral health assessment.

2.2.2. Exclusion criteria

This study has Exclusion criteria; i) Age: adolescents younger than 12 years or older than 16 years. ii) Lack of informed consent: participants who do not return the signed informed consent form, either from themselves or their parents, within two days. iii) medical conditions: adolescents with any systemic diseases or conditions that could affect the accuracy of the oral examination (e.g., untreated severe dental issues, malformations). iv) Incomplete questionnaire: participants who fail to complete the questionnaire provided before the oral examination. v) Orthodontic treatment: adolescents undergoing active orthodontic treatment at the time of examination that could interfere with the detection of dental caries.

2.3. Statistical analysis

Data analysis was conducted utilizing the Statistical Package for Social Sciences (SPSS) version 26.0. Demographic and dietary determinants impacting oral health were computed and presented in tabular format. Statistical analysis using ANOVA and Fisher's post hoc tests at a $p<0.05$ level of significance was used for buffering capacity of beverages. To compare groups, the Chi-square test of independence was employed. Caries status in permanent dentition was evaluated using the DMFT index. Data comparisons were performed within a 95% confidence interval, with statistical significance set at a p-value of 0.05.

3. RESULTS AND DISCUSSION

pH of fruit drinks was in a range from 2.74–3.6 with an average of 3.02, the pH of 100% fruit juices was in a range from 3.4–4.1 with an average of 3.72, the pH of drinks classified in the soda category was in a range from 2.4–3.2 with an average of 2.69, pH of energy drinks was in a range from 3.1–3.65 with an average of 3.54. Around 75/80 of beverages had a pH<4.0, and 5/80 had a pH≥4. Relative beverage erosive zones based on previous studies of apatite solubility in acid indicated: that 20% of the beverages were considered extremely erosive (pH<3.0); 75% were considered erosive (pH 3.0 to 3.99); 5% were considered minimally erosive (pH ≥4.0). These results are represented in Figure 1.

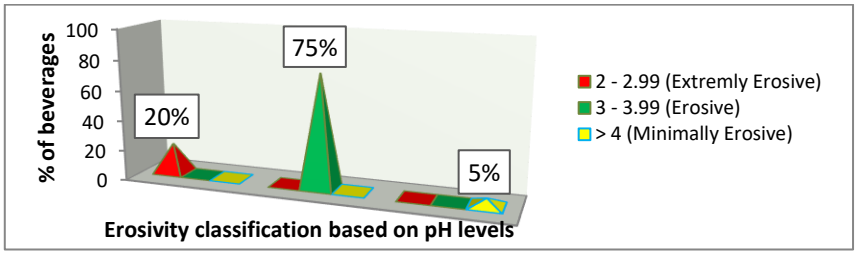

Figure 1. Soft drinks classification in terms of erosivity based on apatite solubility in acid

Brix of fruit drinks was in range from 8.9–12.5% with an average of 10.28%, Brix of 100% fruit juices was in range from 11–14.5% with an average of 12.33%, Brix of beverages classified in soda category were in range from 9.1–13.2% with an average of 11.2% Brix of energy drinks were in range from 11–11.5% with an average of 11.26%. The 100 ml of each drink was titrated with 1M NaOH by adding 0.2 mL till the pH arrived at 5.5 respectively 7. Our results were integrated into statistical analysis using ANOVA and Fisher's post hoc tests with a level of significance p<0.05, in terms of buffering capacity, beverages from the energy drinks category were the highest (when we say the erosion of enamel in this category featured the strongest potential), followed by soda, fruit drinks, and 100% fruit juices. To bring pH back to the neutral level of pH, 7.0, it was required to add an average of 8.72 mL of base, in Table 1. This indicates that to neutralize, the drop of pH it is necessary for a large amount of alkaline-stimulated saliva to be produced when we consume beverages highly acidic like soda and energy drinks.

There was a significant difference in DMFT compared to the frequency of consumption of soft drinks. DMFT increased with an increase in soft drinks consumption per week. The highest DMFT score is 4.36 with a standard deviation of 1.23 was observed in the group consuming more than 16 cans per week, see Table 2. The sodas were distributed into three groups. First, the fruit drinks group includes different flavors like orange, blueberry, forest fruit, and multivitamins. The second group included fruit juices with no added sugar, third one included all carbonated soft drinks (CSD). The 36 of the participants answered they prefer fruit drinks (30%), 20 of them answered 100% fruit juice (16.66%), 55 of them answered they prefer carbonated soft drinks (45.83%) and 9 of them did not consume any of soft drinks, they prefer milk and its products. From 120 children 82 of them prefer fast-food (68.33%) during meals at school, 16 eat chocolates (13.33%), 12 prefer fruits (10%), and 10 of them prefer vegetables (8.3%). These results are presented in Table 3.

Table 1. Description of Brix, pH, buffer capacity, and sugar content of beverages available on the market

Soft drink type	Serving size	°Brix	pH	The volume of base needed to increase pH		Sugar per serving size
				pH=5.5	pH=7.0	
Fruit drinks	1 can/8.45 oz/250 ml	10.28%	3.02	4.8 mL	6.3 mL	26.22 g
100% fruit juice	1 glass/8.45 oz/250 ml	12.33%	3.72	6.4 mL	7.7 mL	25.04 g
Soda	1 can/8.45 oz/260 ml	11.12%	2.69	5 mL	10.4 mL	27.5 g
Energy drink	1 can/8.45 oz/250 ml	11.26%	3.54	6.2 mL	10.5 mL	27 g

Table 2. Frequency of cans consumed, caries status, index during clinical examination

No. of cans consumed for a week	No.	D (Mean±SD)	M (Mean±SD)	F (Mean±SD)	DMFT	
					Mean	SD
None	14/120	1.9±2	0.59±0.55	1.01±1.4	3.5	1.316
1-8 cans (250 ml)	70/120	2.2±1.81	0.55±0.62	1.1±1.33	3.85	1.253
8-16 cans (250 ml)	33/120	2.3±2.01	0.52±0.67	1.09±1.25	3.91	1.31
>16 cans (250 ml)	17/120	2.7±1.95	0.62±0.59	1.04±1.15	4.36	1.23
Total	120/120	2.275±1.94	0.57±0.607	1.06±1.282	3.90	1.27

Table 3. Comparison of attitude in dietary habits and food practice

Variables	N	%	Mean DMFT	SD DMFT	p-value	X2
Soft drinks group					0.05	40.1
Fruit drinks	36	30%	3.45	1.7		
100% fruit juices	30	16.66%	3.37	1.5		
Carbonated beverages (CD)	55	45.83%	3.85	1.9		
Other	9	7.5	3.2	1.9		
Food habits					0.05	120.8
Fast-food	82	68.33%	3.7	2.0		
Vegetables	10	8.3%	2.6	1.4		
Fruits	12	10%	2.95	1.75		
Chocolates	16	13.33%	4.2	1.8		

The current study in its topic was to investigate the relationship between soft drinks and DMFT among adolescents aged 12–16 years in Kosovo. Findings suggest that the majority of participants were highly connected with soft drink consumption. Additionally, the highest prevalence of DMFT was found to correlate with the frequency of soft drink intake also with other various factors such as food habits and type of soft drink consumed. Frequency of soft drink intake was statistically significantly positively correlated with DMFT and this is by previous research done by authors [21]–[24], researches done in adolescents 12 years and older, all of them reported a significant correlation between frequency of soft drink and increase in DMFT. Our first hypothesis is confirmed by the reported DMFT score (4.36) with a standard deviation of 1.23 was observed in the group of patients that consumed more than 16 cans per week, there is a dose-response relationship between sugars and dental caries, this corresponds to the results in Table 2, where dental caries was higher in people who consumed large amounts of soft drinks compared to those who did not. With an increase in consumption of soft drinks per week the DMFT index was higher for those who consumed less, which is to the previous findings of the study from [25] author investigated a significant difference by increasing the frequency of consumption of carbonated drinks, DMFT increased. Otherwise, research done by Palacios [26] found that people who did not consume soft drinks had 39% less expression of the DMFT index than those who consumed them daily, this is also consistent with our results expressed in Table 2, where people who did not consume soft drinks had at least 46.42% less expression of the DMFT index to those who consumed them weekly.

According to Reddy *et al.* [27] sugar and acid content of beverages is the explanation for tooth decay and this is the reason that leads to high pH drops of dental plaque, which is followed by high dental issues. The explanation for that is the consumption of sweetened beverages and fruit juice with sugar as the main ingredient. Dental caries is associated with the frequency consumption of acidic beverages, but properties like pH and titratable acidity of acidic beverages are still under debate. All tested beverages had an acidic pH, below the critical pH level that can lead to enamel loss. Our results from pH measurements are consistent with other authors, for example, we determined the pH of beverages around (93.75%, 75/80) pH were below 4, and (6.25% 5/80 had a pH >4), [28] found that majority (93%, 355/380) of beverages had a pH below 4.0 and 7% (25/380) had a pH ≥4, [29] found that 88% of all beverages tested had a pH <4, and 12 had a pH ≥4. Classifying beverages on apatite solubility in acid indicated that most of the soft drinks found in the market, more than >50% are erosive, [28] concluded 54% are erosive, [29] also showed more than 51% were erosive (pH <4). Our study showed that the majority of soft drinks have a pH from 2.4 to 4.1 with an average of 3.35, quite close to results from [28] who reported an average of 3.44 for soft drinks. The reported amount researches of sugar found in soft drinks usually is between 1% and 12% sugar, in the form of sucrose, glucose, or fructose [2] these results are similar to our findings expressed in brix degree presented in Table 1 [30] reported the sugar in term of grams for different type of soft drinks found in the market, red bull 39 g/355 ml, Coca-Cola classic 39 g/355 ml, diet coca cola 0 g/355 results are similarly to ours, presented in Table 1, where red bull 35.64 g/330 ml included on energy drink type, cola classic 36.3 g/330 ml and diet cola 0 g/330 ml both of them were included in soda type. Other research has been done and the author reported that energy drinks had the most erosive potential due to their significantly greater buffering capacity compared to carbonated drinks and fruit juices where energy drinks had the highest buffer capacity followed by soda, 100% fruit juices, and fruit drinks. Our results expressed a mean DMFT value of 3.9 with an SD of 1.27, compared to countries in the region where [31] reported Macedonia a DMFT of 3.55 with an SD of 2.99 and [32] reported Albania a DMFT of 4.9 the results close to each other, these results express a same situation with a high DMFT prevalence of caries among the adolescents in Balkan. Other authors' researches between soft drinks, sweetened juice, desserts, and DMFT there were found to have a significant positive correlation [33], by results expressed in Table 4 there is a strong positive correlation between food habits like chocolates [34], fast food with increased DMFT of participants who consumed them instead of those who eat as meal fruits and vegetables, these two components were associated with protective role and lower DMFT index our results found from. In gender and age context, especially gender our results showed that girls had a higher presence of dental caries compared to boys many other authors reported

the same [35], [36]. The reason for this could be an earlier eruption of teeth in females and prolonged exposure to the oral environment [37].

Table 4. DMFT in relation to gender and age

Variables	No	%	Average of DMFT	SD of DMFT
Age				
14-16 years	64	53.3%	3.98	1.9
12-14 years	56	46.6%	3.55	1.3
Total	120	100%	3.76	1.6
Gender				
Female	67	55.83%	3.91	1.7
Male	53	44.16%	3.62	1.4
Total	120	100%	3.76	1.55

4. CONCLUSION

The study's findings have significant implications for improving dental health by informing public health guidelines, educational programs, and preventive dentistry strategies. Highlighting the harmful effects of acidic and sugary beverages on dental health, the research can guide more effective dietary recommendations and oral health education, especially for adolescents. Moreover, these results could support policy changes, such as stricter labeling and marketing regulations, and serve as a basis for future research on mitigating dental erosion and caries risk. The implications of our findings are critical for public health and future oral health strategies. The high prevalence of dental caries among Kosovo school children, exacerbated by the consumption of highly erosive soft drinks, underscores the need for targeted interventions. Recommendations include reducing the intake of acidic beverages, choosing less erosive options, and promoting a diet rich in fruits and vegetables. This study also emphasizes the importance of regular oral hygiene practices, such as brushing with fluoride toothpaste and attending biannual dental check-ups. These insights are not only valuable for improving dental health outcomes in Kosovo but can also guide policymakers and health professionals in developing effective prevention strategies and public health campaigns in similar contexts.

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