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Correlation Between the Incidence of Tooth Decay in Children and Their Eating Habits

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Summary

Introduction: Oral health is a major indicator of quality of life and level of overall health. The WHO (2022) considers oral diseases to be among the most common non-communicable diseases, affecting almost 3.5 billion people worldwide.

Objectives: The main objective of the study is to identify nutrition-related risk factors for tooth decay in children aged 5-12 years.

Methods: The survey sample consisted of 165 children and their parents. Data collection took place from October 2022 to March 2023. For data collection, a standardized questionnaire Oral Health Questionnaire for Children according to WHO (2013) and a non-standardized questionnaire were used.The condition of the oral cavity of children was determined by clinical examination of KPE and QHI indices, Kariogram, Nutrition Protocol. Statistical analysis of the data was performed using the statistical program SPSS 13.0, Program R and Microsoft Office 365 Excel.

Results: Of the total number of respondents, 44.8% of children are overweight. Sweet snacks are consumed several times a week by 52.1% of children and sweetened drinks by 40.0% of children. An examination of the KPE index points to a high to very high risk of tooth decay in 34.5% of children. The results of the Kariogram show a high risk of tooth decay in 70.3% of respondents.

Conclusion: Maintaining good oral health throughout life is an integral part of prevention. The incidence of tooth decay in children and adolescents in Slovakia is still alarming, despite a slowly decreasing tendency in recent years.

Keywords Risk factors for tooth decay. Cariogenic diet. Cariogram. Index QHI. Nutritional protocol. Prevention.

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Introduction

According to the World Health Organization (WHO, 2022), oral health is a key indicator of overall health, well-being, and quality of life. The mouth reflects a person's overall health at every stage of life. The oral cavity is the first point of contact between the digestive tract and the external environment.

The health of the oral cavity in terms of tooth decay is affected by the daily intake of carbohydrate-rich food and drinks. In addition to the development of tooth decay, excessive consumption of carbohydrate diets, a sedentary lifestyle, lack of sleep, stress, but also genetic factors lead to the development of overweight or obesity. A large-scale Chinese study of more than 32,000 children confirmed the existence of an inverse link between tooth decay and BMI compared to a group of children of normal weight. Children who were overweight and obese were more likely to develop primary tooth decay (Liang, Zhang, et al., 2016). However, some studies report a

minimal impact of obesity on the development of tooth decay or tooth decay on obesity, however, studies have been conducted on small samples of respondents. Marshall et al. (2007), based on the findings of the conducted study, confirm a high incidence of tooth decay in obese children. A study conducted in the United Kingdom focused on determining the determinants of tooth decay and obesity, and its results clearly confirm the link between a higher frequency of intake of sugary foods and drinks and overweight/obesity of a child. Sugar intake in food and beverages is one of the main risk factors for tooth decay. Klamárová (2019) states that the taste for sweets has been evoking a feeling of satisfaction and joy in humans since ancient times. Trnková, Balogová (2019) state that already during intrauterine development, the center of taste and important neuroendocrine pathways affecting adipogenesis and the regulation of energy metabolism are formed. Taste cells produce neuropeptide Y, which is responsible for actively seeking sweets, which becomes a big problem in children with a higher BMI when treating tooth decay and the need to change eating habits. The secretion of neuropeptide Y is also increased when consuming artificial sweeteners. Therefore, when identifying the risk of tooth decay, it is a very important part of the examination of the child's eating habits. As part of the nutritional history, it detects the type of sugar ingested, the amount, frequency and consistency of sugary foods and drinks. Furthermore,highly important is the information on the intake of sugars with the main meal and between the main meals, the so-called intermediate meals - snacks (Kovaľová et al., 2010). When assessing nutritional risk, it is advisable to base the assessment on dietary data during the normal working week and especially during the weekend, when eating habits are usually different.Trnková (2022) states that in today's hectic times, children tend to consume semi-finished products and use fast food establishments more often due to lack of time. Follow-up nutritional counseling in a dental hygiene clinic is an important part of the first initial examination, especially if there is a high risk of tooth decay. The primary goal is to educate the patient and parents which foods and drinks are a source of sugars and pose a nutritional risk to tooth decay. It is also important to know about suitable dietary alternatives, sugar substitutes and adjusting the time of sugar intake. Natural sugars contained in fresh fruits and vegetables or dairy products do not play any significant role in the development of tooth decay. Polyphenols, calcium, water and fiber from fruits or vegetables stimulate saliva, cow's milk even protects teeth from tooth decay because it contains calcium and casein. Sugars in the regular diet contain sucrose, glucose, fructose, lactose and maltose, i.e. sugars that are highly cariogenic. According to the WHO, free sugars are added to juices, syrups, fruit juices, honey (Trnková, 2020; Tungare, Paranjpe, 2022).

Compliance with the recommendations is checked at each subsequent visit and the recommendations are amended as necessary. Any changes in the child's eating habits must be gradual, understood by patients and parents. An important part of nutritional interventions is also the motivation for change that promotes oral health (Hellwege, 2018). Health literacy, as stated by Trnková, Kilíková (2021), is one of the options for preventing health problems and protecting health, but also a way to manage newly arisen situations and health-related problems. If a nurse in the role of an educator supplements the text with appropriate images and photographs, memorability increases by up to 30%.

The objective of the research study was: To identify nutrition-related risk factors for tooth decay as well as to define their impact on the incidence of oral and general diseases.

The set of respondents consisted of children aged 5 to 12 and their parents who visited a selected dental practice in Pre8ov DENT-PREV s.r.o., where they focus primarily on child care. Therefore, it is a nest selection of a specific population. The exploratory study involved 165 child respondents, of which 79 (47.9%) boys and 86 (52.1%) girls. The respondents were between the ages of 5 and 12. For the sake of clarity of the evaluated data, the respondents were categorized as follows: children aged 5-6 years, 7-10 years, 11-12 years (Table 1).

Table 1 Age of respondents

	n	%	*Age distribution for work purposes*	n	%
5 years	**12**	**7,3**	**5-6 years**	**27**	**16,4**
6 years	15	9,1			
7 years	17	10,3	**7-10 years**	76	46,0
8 years	14	8,5			
9 years	24	14,5			
10 years	21	12,7			
11 years	33	20,0	**11-12 years**	62	37,6
12 years	29	17,6			
TOGETHER	165	100	TOGETHER	165	100

(Source: Own processing)

The most numerous category of respondents was the category of children aged 7-10 years (76; 46%), followed by the category of children aged 11-12 years (62; 37.6%) and the category of children aged 5-6 years, consisting of 27 respondents (16.4%) (Table 1).

The children aged 5-6 years are at risk for tooth decay. This period of age is characterized by the pruning of the first permanent molars (molars). At the same time, it is statistically the most evaluated category by the WHO in terms of the development of oral diseases in children. It is followed by the age category is children aged 12. The study is primarily focused on the assessment of the age category of children 11-12 years old, in whom the second permanent molars are erupted, the complete replacement of milk teeth with permanent ones is completed. Moreover, it is a critical period for the beginning of the development of periodontal diseases. The age category of 7-10 years is specific for the period of mixed teeth, during which milk teeth are replaced with permanent ones.

In order to assess the risk factors for tooth decay, it is also important to know the health status of the respondents, which we investigated through an anamnestic questionnaire completed before the clinical examination of the respondents, which consisted of an examination of:

1. *Tooth decay index – the kpe/KPE index* (caries/filling/extraction; dmft/DMFT decay/missing/filledteeth) monitors the number of teeth with caries, fillings and extracted teeth. Lowercase letters indicate the index in the deciduous dentition, uppercase letters in the permanent dentition. The resulting value of the kpe/KPE index is obtained by the sum of the examined teeth according to kpe/KPE, multiply by 100 and the resulting value is the kpe/KPE index expressed as a percentage. The values of the risk degree are shown in Table 2.

Table 2 WHO Quantification for the KPE Index

Value (%)	Risk
0,0 – 1,1	**very low**
1,2 – 2,6	low
2,7 – 4,4	Average
4,5 – 6,5	high
6,6 >	very high

(Source: Moreno-Quispe et al., 2018)

1. *the state of oral hygiene of the respondent* was identified through the dental-hygienic index - QHI index, by staining dental plaque. The detection of quantity, coating site and acidity was carried out by a three-component detection device (Triplaque GC). By detecting the biofilm, the degree of the patient's care for oral hygiene can be determined, which the patient (child/mother) sees directly in the mirror. The index also helps in the motivation and instruction of the patient/parent. After applying the detection product to the teeth, three scales of plaque colors are evaluated: pale pink: fresh plaque not older than 12-24 hours, dark pink to purple-blue: plaque older than 48-72 hours, and turquoise: the plaque is acidic and the individual receives a diet rich in sugars. The results are recorded in a diagram and each tooth is evaluated:Grade 0 – no plaque, grade 1 –

isolated colonies, grade 2 – distinct plaque around the edge of the gingiva, grade 3 – plaque covering 1/3 of the cervical surface of the tooth, grade 4 – plaque covering 2/3 of the tooth surface, grade 5 – plaque covering more than 2/3 of the tooth surface. The resulting average value of the index is calculated by summing all numerical values, which are divided by the number of teeth examined (Hellwege 2018; Kovaľová et al. 2010).

2. *the Nutrition Protocol* (Hellwege 2018) was used to analyze eating habits, focusing on information on food and drink intake over a 24-hour period. The data were compared with the data completed in the questionnaire. In the case of a pediatric patient, the parent protocol was filled out. The scheme records the intake of food and drinks during a normal day. Subsequently, the so-called Stephan's curve was created, which reflects the number of times the pH has dropped in the oral cavity. The demineralization and remineralization time over a 24-hour period is calculated, where the green bars represent physiological neutral pH levels (6.75-7.25) in the mouth and the red ones represent a drop in pH below 5.5. The time of intake of food and drinks is counted in the time of demineralization, plus 30 minutes to balance the pH of saliva in the mouth. After the Stephan curve is created, the demineralization time in minutes (hours) is added up in the red column and the resulting value is written to the protocol. The time of brushing your teeth is also recorded in the protocol. Based on the results of the nutrition protocol, the consistency of the meals, the time of intake with the time of brushing your teeth, the type of drinks consumed and the amount of meals between main meals are further evaluated. Subsequently, it is necessary to recommend suitable dietary alternatives, sugar substitutes to the patient and adjust the time of their intake (the adjustment is recorded with a red pen directly in the protocol diagram).
3. *for caries risk assessment, the interactive computer program Cariogram* (Cariogram/Caries Risk Assessment/CAR)was used, which graphically illustrates the biological, etiological risks of tooth decay and provides guidance on the solution strategy for the individual. It finds out information about the number of bacteria, carigenicity of the diet and other related factors of tooth decay. It provides the so-called *Risk profile of tooth decay*. In the program, bacteria are shown in red on the graph, carigenicity of the diet in dark blue, susceptibility to caries in light blue Other associated risks are shown in yellow or orange. The green color means a chance to avoid tooth decay. Values of 0-3 are assigned to ten factors: *caries experience, associated diseases, diet/composition, diet/ frequency, plaque, amount of Streptoccocusmutans, fluoridation, amount of saliva, saliva buffer capacity (pH).* When you enter the seven factors, a karyogram is already displayed, where individual items by color will be evaluated as a percentage (%).
4. *In children, anthropometric data* (weight, height/BMI) were investigated as a risk factor for obesity that affects the development of tooth decay in relation to the child's eating habits. Standard values of the BMI index in children are given in the professional guideline of the Ministry of Health of the Slovak Republic. Percentile values and z-scores of BMI are defined separately for girls and separately for boys. A result of the 5th percentile and below represents malnutrition, a result between the 5th and 85th percentile means a normal healthy body weight, more than the 85th percentile represents overweight and the 95th percentile or more represents the state of obesity (Bulletin of the Ministry of Health of the Slovak Republic, 2012).

All of the above-mentioned data collection steps were preceded by the signing of an informed consent of the children's legal guardians, who were given consent to include the children in the research study. Parents then filled out a questionnaire that consisted of two parts: a standardized according to WHO (2013) Oral Health Questionnaire for Adults and a non-standardized one, through which we obtained additional information in relation to risk factors for the development of oral diseases.

The data collection was carried out from October 2022 to March 2023. We addressed 200 respondents, while 165 respondents (82.5%) expressed their consent to the exploratory studyand clinical examination in writing. The most

common reason for the refusal of legal guardians to participate in the study was their unwillingness to cooperate.

Data obtained from the clinical examination and questionnaire were encoded and subsequently statistically evaluated We considered statistically significant results to be those in which *the p*- value was p< 0.05.

The anthropometric data of the children such as height and weight were obtained and thenthe BMI weight and height index was calculated.

(Source: Own processing)

Table 3 Results of BMI assessment in child respondents

Evaluation of the result of body weight	*Girls*		*Boys*	
	n	%	n	%
Malnutrition (5 percentile and below)	7	8,1	7	8,9
Normal body weight (between the 5th and 85th percentiles)	55	64,0	47	59,5
Overweight (more than the 85th percentile and less than the 95th percentile)	19	22,1	18	22,7
Obesity (95th percentile and above)	5	5,8	7	8,9
TOGETHER	86	100	79	100

The results indicate that 19 (22.1%) girls were overweight, 5 (5.8%) were obese and 7 (8.1%) girls were malnourished. In boys, the results were similar, 7 (8.9%) were malnourished, the same number were obese, and 18 (22.7%) boys were overweight. The highest incidence of overweight in 10 (52.6%) girls was aged 11-12 years and in 8 (42.1%) girls aged 7-10 years. Girls aged 7-10 and 11-12 years also had obesity.

The questionnaire also included an item mapping the incidence of general diseases in respondents, the results of which we compared with the data in the anamnestic questionnaire, which is part of the patient's dental card.

(Source: Own processing)

Table 4 Overview of respondents' overall illnesses

General diseases	*Girls*		*Boys*	
	n	%	n	%
No general diseases	77	89,5	69	87,3
Asthma	5	5,8	3	3,8
Heart disease	0	0	0	0
Diabetes	1	1,2	0	0
Autoimmune diseases	0	0	0	0
Oncological disease	0	0	0	0
Epilepsy	0	0	0	0
Rheumatism	0	0	0	0
Other	3	3,5	7	8,9
TOGETHER	86	100,00	79	100

There were 77 (89.5%) girls and 69 (87.3%) boys. 5 (5.8%) girls and 3 (3.8%) boys had asthma. One girl (1.2%) had diabetes. In the Other three (3.5%) option, girls reported allergies to pollen, eggs and bananas. Heart murmurs, allergies to pollen, grass, plants, or the occurrence of atopic eczema were reported by 7 (8.9%) boys (Table 4).

Moreover, the eating habits of the respondents were investigated.

Fresh fruit is consumed every day by 60 (36.4%) respondents, several times a week by 68 (41.2%). *Biscuits, biscuits, croissants* every day is 47 (28.5%) children and several times a week 86 (52.1%). Various sweetened *sodas, coca-colas* and other sugary drinks are consumed by 60 (36.4%) respondents, 38 (23%) at least once a week and 28 (17%) respondents. Only 36 (21.8%) children had never drunk sugary sodas and cola. Tea with sugar/ fruit tea was a daily part of the diet for 15.2% of children. *Jam/honey* is part of the diet every day for 10 (6.1%) children, once a week for 50 (30.3) and several times a month for 63 (38.2%) respondents. *65* (39.4%) of the respondents drink chewing gum containing sugar a few times a month and 19 (11.5%) children several times a week. *Sweets or candies* are a daily part of the diet of 38 (23%) children, 80 (48.5%) several times a week and 25 (15.2%) several times a month. Only 4 children (2.4%) consume sweets several times a day. An interesting figure is the occasional or no drinking *of energy drinks* in 144 (87.3%) children and several times a month in 14 (8.5%) children. *Ionic drinks are* occasionally or never consumed by 145 (87.9%) and 15 (9.1%) children several times a month. Energy drinks contain methylxanthin, caffeine, taurine, acai, B vitamins, maltodextrin, inosite, carnitine, creatine. Ionic drinks contain high amounts of simple sugars (glucose, fructose), as well as carnitine, taurine, glutamine. *72* (43.6%) child respondents indulge in smoothies and similar drinks several times a month. Ketchup and mustard are among the snacks with a high content of hidden sugars, while as many as 43

(26.1%) children consume them every day, 48 (29.1%) several times a week and at least once a week 52 (31.5%) respondents (Table 5).

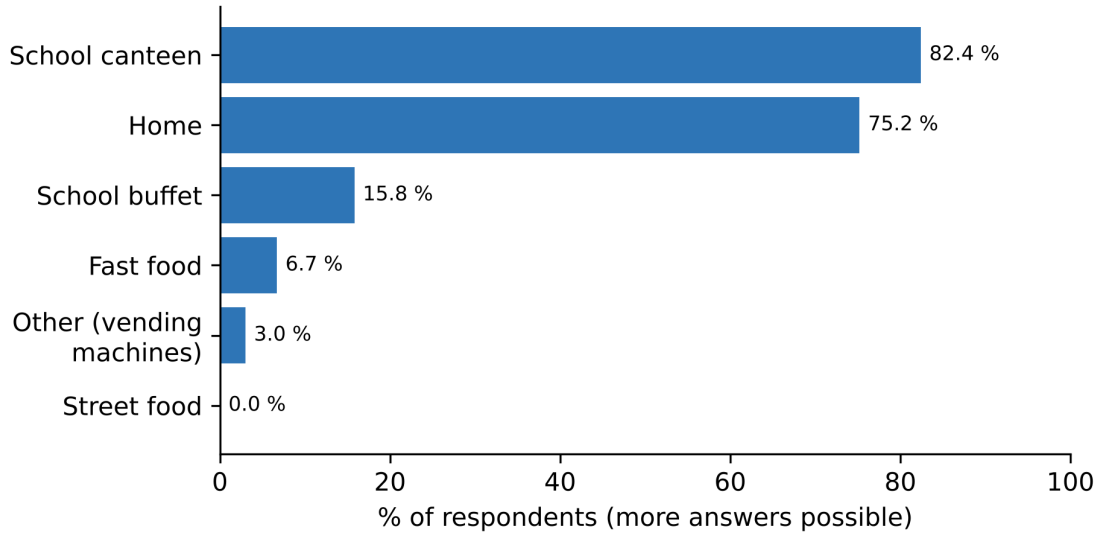
Table 5 Frequency of intake of beverages and food

	Several times a day		*Every day*		*Several times a week*		*Once a week*		*Several times a month*		*Sometimes/ Never*	
Food, drinks	n	%	n	%	n	%	n	%	n	%	n	%
Fresh fruit	22	13,3	60	36,4	68	41,2	13	7,9	2	1,2	0	0
Biscuits, biscuits, cakes, croissants, ..	2	1,2	47	28,5	86	52,1	21	12,7	9	5,5	0	0
Limonády, Cocacola,..	0	0	3	1,8	28	17,0	38	23,0	60	36,4	36	21,8
Jam/honey	0	0	10	6,1	17	10,3	50	30,3	63	38,2	25	15,2
Chewing gum containing sugar	0	0	2	1,2	19	11,5	19	11,5	65	39,4	60	36,4
Sweets/candies	4	2,4	38	23,0	80	48,5	15	9,1	25	15,2	3	1,8
Milk with sugar and grank	0	0	7	4,2	31	18,8	34	20,6	41	24,8	52	31,5
Tea with sugar, fruit tea	3	1,8	25	15,2	31	18,8	35	21,2	38	23,0	33	20,0
Energy drinks	1	0,6	1	0,6	0	0,0	5	3,0	14	8,5	144	87,3
Ion supply drinks	1	0,6	1	0,6	0	0,0	3	1,8	15	9,1	145	87,9
Smoothies and other similar foods	0	0	0	0	6	3,6	12	7,3	72	43,6	75	45,5
Ketchup/mustard	5	3,0	43	26,1	48	29,1	52	31,5	17	10,3	0	0

(Source: Own processing)

Of all respondents, 136 (82.4%) most often use the school canteen and 124 (75.2%) use home cooking for meals. As for other options, 26 (15.8%) children buy food in the school cafeteria. With the possibility of a free answer, 5 (3.0%) respondents mentioned break machines or vending machines for sweets and drinks (Fig. 1). Vending machines for fruit, various drinks and sweets, or sweetened milk, the so-called break machines, are slowly getting into schools. There is a possibility of risk in vending machines for sweetened drinks, sweetened milk and sweets.

Figure 1 Graphic representation of children's preferred eating places (Source: Own processing)



Clinical trial evaluation results

The results of the clinical examination of the KPE index in the monitored group showed *a very high risk* in 24 (14.5%) respondents, *a high risk* in 33 (20.0%) and *an average (medium) risk* in 48 (29.1%) respondents (Table 6).

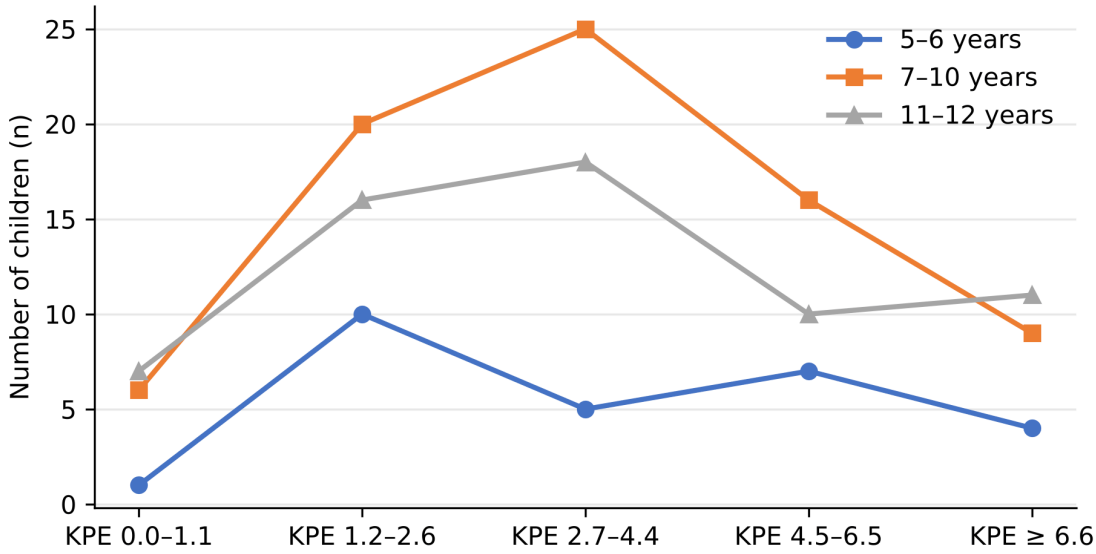
Table 6 Results of the KPE index assessment in children aged 5-12 years

KPE index	n	%	diameter	SD	Risk
KPE 0,0-1,1	**14**	**8,5**	**1,1**	**0**	**very low**
KPE 1,2-2,6	46	27,9	1,9	0,4	low
KPE 2,7-4,4	48	29,1	3,5	0,5	Average (Medium)
KPE 4,5-6,5	33	20,0	5,5	0,6	high
KPE 6.6 and above	24	14,5	7,9	1,3	very high
	165	100	3,98	2,8	

(Source: Own processing)

High average values of the KPE index were shown by children aged 7-10 years (5.53; SD 2.2) and children 11-12 years old (5.73; SD 2.42) at the level of medium to very high risk of tooth decay (Fig. 2).

Figure 2 Graphical representation of the KPE index's rating by age (Source: Own processing)



Evaluation of the results of the QHI index examination

The dental microbial plaque, its quantity, locations, acidity (cariogenicity) and the degree of oral hygiene care, was detected by a three-component detection dye. The available literature indicates that values of 3.0 to 5.0 indicate a high risk of developing oral diseases. 82 (49.7%) children had average oral hygiene and 61 (36.9%) respondents had poor oral hygiene (Table 7).

Table 7 QHI Index Assessment Results in Children 5-12 Years of Age

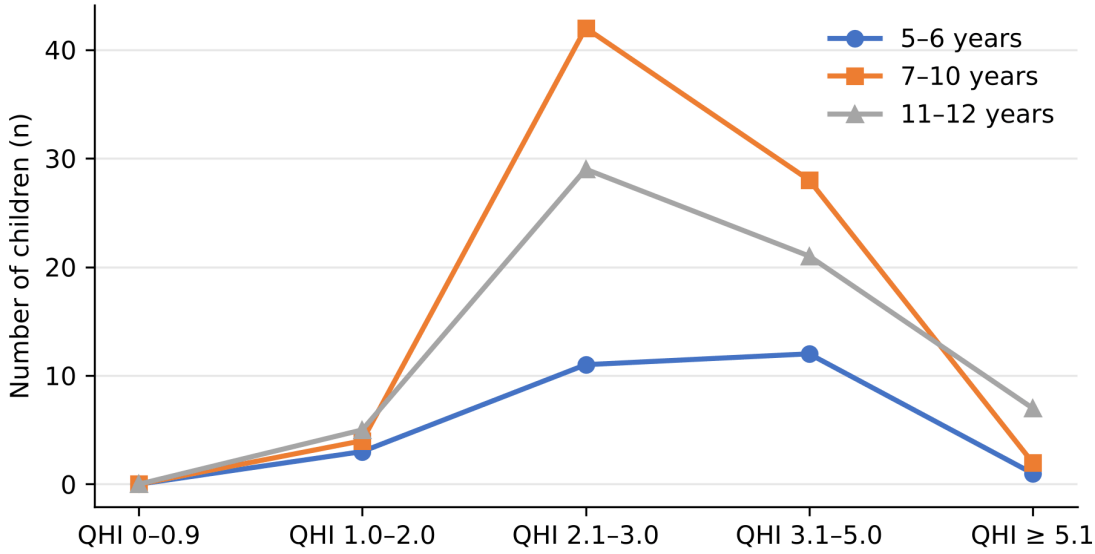
QHI index	n	%	diameter	SD	Oral hygiene status
QHI 0-0,9	**0**	**0,0**	**0,0**	**0,0**	**Very good (satisfactory)**
QHI 1,0-2,0	12	7,3	1,8	0,3	Okay
QHI 2,1-3,0	82	49,7	2,5	0,3	Average

QHI index	n	%	diameter	SD	Oral hygiene status
QHI 3,1 -5,0	61	36,9	3,6	0,5	Bad
QHI 5.1 and above	10	6,1	5,7	0,4	Very poor (unsatisfactory)
	165	100	2,7	0,3	

(Source: Own processing)

Even when assessing the state of oral hygiene using the QHI index, respondents aged 7-10 years and 11-12 years showed the worst results (Fig. 3). The average value of the QHI index for a high risk of tooth decay and poor to unsatisfactory oral hygiene was 4.55 (SD 1.34) for the age group of respondents 7-10 years and 4.7 (SD 1.56) for the age group of 11-12 years.

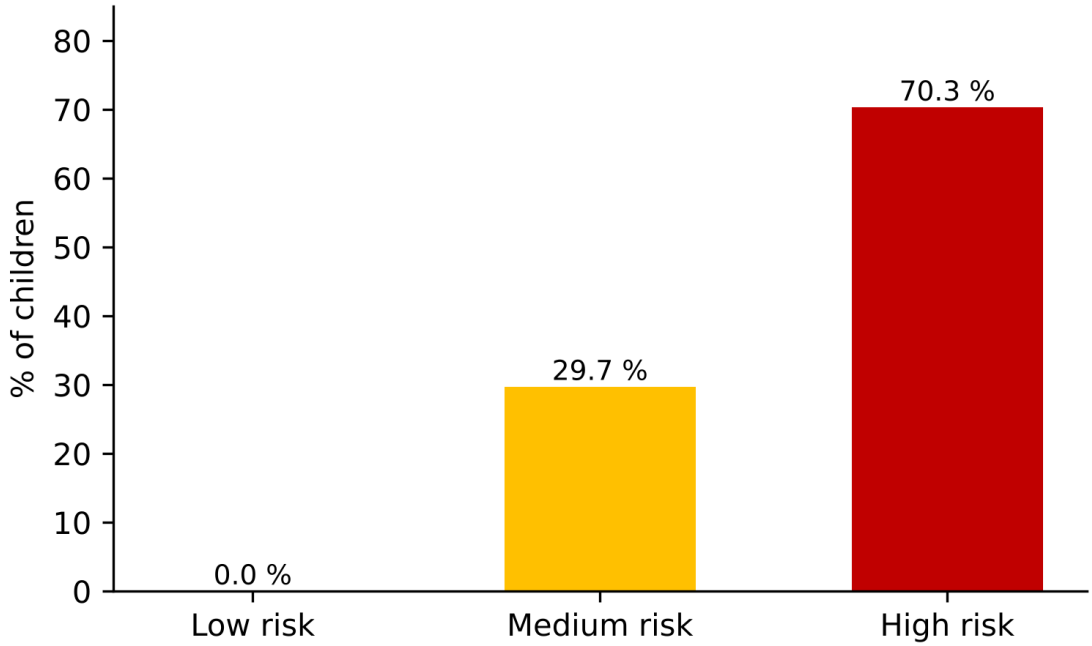
Figure 3 Graphical representation of the QHI index by age



(Source: Own processing)

By evaluating the results of the PC program Cariogram, it can be concluded that up to 70.3% (n = 116) of respondents have a high risk of tooth decay (Fig. 4).

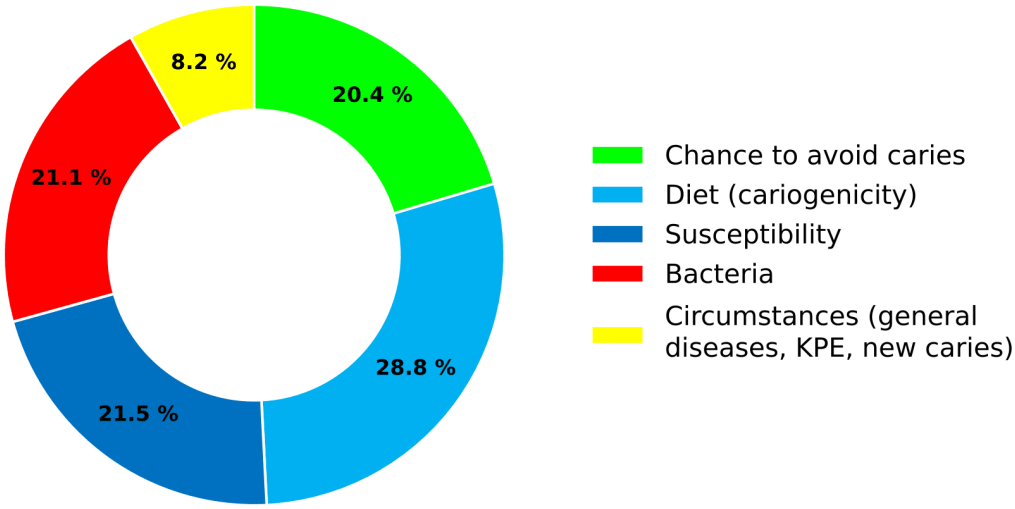
Figure 4 Graphical representation of the degree of risk of tooth decay in children 5-12 years old



(Source: Own processing)

The average risk of tooth decay based on the evaluation according to the model in the Kariogram of all respondents to the study is shown in Figure 5. The most alarming sector appeares to be the area of carigenicity of the diet (28.8%) and the related susceptibility to the development of new tooth decay.

Figure 5 Graphical representation of the average risk of tooth decay of respondents according to the Karyogram model

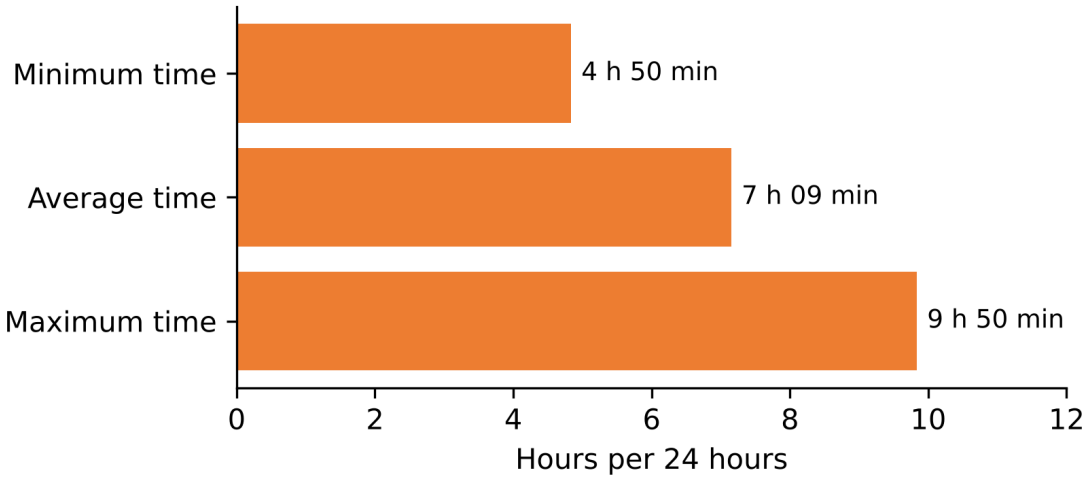


(Source: Own processing)

Evaluation of the results of the examination of eating habits - Nutrition protocol

The frequency of intake of basic cariogenic foods and drinks is also of importance. Therefore, the consistency of the diet intake, the amount and frequency of sugar intake and their duration of exposure to tooth enamel were monitored. The interval of pH decrease in the mouth until the return to neutral values was mostly observed. A drop in saliva pH below 5.5 is risky as the tooth enamel is demineralized. In connection with the drop in pH below neutral values, Klamárová (2019) states that the alternation of the phases of demineralization and remineralization, which results from frequent dietary intake, is critical. The author also states that it takes about 30 minutes for the pH to drop below 5.5 after eating a non-cariogenic food. A low pH can persist for several hours in an unremoved microbial coating. After the evaluation of the Respondents' Nutritional Protocols, it was found that the average time to drop pH below 5.5 in one day was 7 hours and 9 minutes (SD 1.05) (Fig. 6).

Figure 6 Graphical representation of the average time spent consuming a cariogenic diet over a 24-hour period



(Source: Own processing)

The aim was to identify nutrition-related risk factors for tooth decay in children aged 5-12 years, assuming that the value of the KPE and QHI index may be influenced by influenceable factors, e.g. BMI index, consumption of certain foods and beverages.

By statistical analysis, it was found that the value of the KPE and QHI index is statistically significantly influenced by BMI (P=2.2x10-16), chewing gum containing sugar (P=0.02), tea with sugar or fruit tea (P=0.02). The KPE and QHI indices in relation to the chance of avoiding tooth decay, cariogenicity of the diet, susceptibility to tooth decay, bacteria and general diseases appear to be statistically significant, since the P< value was 0.001 for all risk factors.

Conclusion

According to the WHO Global State of Oral Health Report (2022), Slovakia is one of the countries with the highest incidence of tooth decay in milk dentition in children aged 1-9 years (for 2019: 45.8% - 53.2%), in permanent dentition in children over 5 years of age, the prevalence is at the level of 40.6% - 55.7%. The development of tooth decay is significantly influenced by the intake of a carbohydrate diet, as well as the development of overweight and obesity, diabetes, metabolic disorders, or immunity. Karki et al. (2019) found in their clinical study that overweight/obesity and tooth decay clearly have common risk factors, consisting in diet.

Based on the results above, it can be concluded that the state of oral health in children is very alarming, especially between the ages of 7 and 12 with mixed dentition. The cariogenicity of diet also presents one of the most risk factors for tooth decay in children. With the results of their study, Naki, Mori-Suzuki (2023) confirm that excessive consumption of sugars in the diet has a direct impact on the development of tooth decay and increasing kpe/KPE (dmft/DMFT) values from childhood, creating a predisposition to the development of tooth decay in adulthood.

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