Correlations Between *p*H Values of Oral Fluid and Dental Caries Epidemiologic Indicators in Children Aged within 6-12 Years

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The aim of this study was to evaluate the correlations between the pH values of oral fluid and the epidemiologic indicators of dental caries in children aged between 6-12 years. Clinical examinations were performed on 1517 children and the analysis was made in groups of 6-8 years old (n=701) [male (n=353), female (n=348)], and 9-12 years old (n=786) [male (n=426), female (n=360)]. The research included the record the pH values of the oral fluid and clinical examinations for evaluation of the state of oral health, in conformity to the codes of the OMS carious affection level. For the determination and the record of pH values of the oral fluid we used GC Saliva pH Indicator kit. The study followed defs, deft, dmfs, dmft *epidemiologic indices of dental caries. The determined values of oral fluid pH were between 5.0 and 6.4. The obtained values of indices in all studied groups and subgroups demonstrated the significant statistical difference between at least two values ($p < 0.001$). 72% of the studied group presented with at least a dental surface affected in deciduous teeth, while only 40% of the children presented a carious process on the permanent teeth. The occlusal surface was the most frequently affected by dental caries, followed by the proximal surfaces (mesial and distal) and last being smooth surface caries. The study demonstrated the correlation between acidic values of oral fluid pH and the dental caries in the study group.*

Keywords: children aged between 6-12 years, oral fluid pH, dental caries

The oral cavity is the most complex, most accessible microbial ecosystem of the human body. Teeth, gingiva, tongue and oral mucosa provide different surfaces for colonization, but they do not provide uniform and identical conditions for this [1]. Saliva has a major role in preserving the oral cavity homeostasis. As other body biological fluids (blood, lympha), saliva is a biomarker used in the assessment of various pathological conditions of human organism [2]. The *p*H of human saliva has been described previously, with varying results in the wide range of 5.3–7.8, depending on the stimulation state [3,4]. Dental caries in the present time represent the most wide spread chronic disease amongst children, it affects children five times more than asthma and seven times more frequent then seasonal allergies. Yee et al. [5] reported that in third world countries, dental caries are the fourth most expensive disease to treat. The public oral health programs combined with other preventative measures have a major role in dental prophylaxis. Detection and reliable evaluation of carious lesions that are reproducible have been seen as a challenge [5-7]. Saliva, sugar and bacteria determine the apparition of a combination that may induce teeth decay, because the combination of carbohydrate and protein molecule adhere to the teeth and so start the formation of dental plaque. Although, many oral bacteria also adhere, only the S. mutans is able to cause caries. Hydrolysis of sucrose represent only a portion of process, which release of the fructose, and the glucose undergoes further polymerization (fig. 1) [8].

The bacteria use the fructose in a metabolism process of glycolysis to get energy and the end product of glycolysis under anaerobic conditions is lactic acid (fig. 2).

The lactic acid creates extra acidity to decrease the pH to the extent of dissolving the calcium phosphate in the tooth enamel leading to the apparition of a cavity [9].

Dental caries are frequently measured through DMFT index. [6,7,10]. This value was applied on a large scale for evaluating dental caries on a population of people, to create a plan for the public health system [11]. The DMFT index was introduced for the first time in 1938 by Klein et al [12] as an accumulative measure that indicate the appearance of dental caries, including past and present dental caries. In 2000, Professor Douglas Bratthall proposed a new Index - Significant Caries Index to draw attention to individuals with the highest values of the DMF-T (CAO-D) index. The SiC index is the mean value of the CAO-D index for on third of the study group with the highest values of this index [13]. DMFT index has been used for over 76 years and still

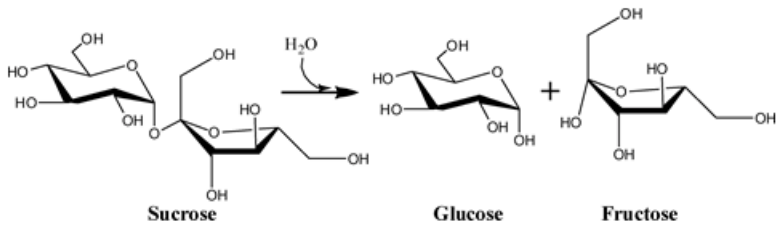

Fig. 1. Hydrolysis of sucrose

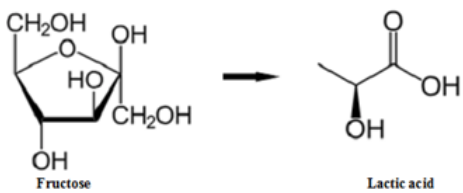

Fig. 2. Formation of lactic acid

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remains the most frequently used epidemiologic index for evaluating dental caries [14].

The aim of the study was to evaluate the correlation between the *p*H of oral fluid and the epidemiologic indicators of dental caries that affect deciduous and permanent teeth in a study group of children aged between 6-12 years.

Experimental part

Materials and methods

The experimental group included 1517 children aged between 6-12 years, divided in two subgroups: 6-8 years old (n=701): male (n=353); female (n=348); and 9-12 years old (n=786): male (n=426); female (n=360). The gender of the studied groups was represented by 779 (51.35%) male children and 708 (46.67%) female children. The purpose and the stage of development of the study was explained, after which informed consent was signed by the patients' parents. Clinical examinations were performed on children's of schools from Cluj-Napoca, Bucharest and Tg. Mures, under optimum comfort for children's and adequate light, using single-use dental examination kits (probe, clip and mirror), special attention being paid to the location of affected dental structures. The evaluation included the record of the oral fluid pH values and of the clinical examinations of the oral health state in conformity to the codes of the OMS carious affection level.

For the determination and the record of pH values of the oral fluid we used GC Saliva *p*H Indicator kit (fig. 3).

Fig. 3. GC Saliva *p*H Indicator used in study (left); salivary chart indicating a *p*H value of 6.2 for the used strip (right)

Children patients have been trained to collect saliva in disposable cups. The *p*H test strips were placed into the collected saliva and after 10 s we checked the color shade of test strip. The obtained color shade were compared with the kit diagram.

The second part of the study followed epidemiologic indices of dental caries (*defs, deft, dmfs, dmft*). All of the obtained data were statistically interpreted. The descriptive statistical elements were calculated then the data were presented by using centralized indicators, localized indicators and distributed indicators. The normal distribution was tested using the Shapiro-Wilk test. Variants were tested with the F test. The analysis of three or more probes was tested by the ANOVA or Kruskal-Wallis. To compare two unpaired probes the T test (Student) or Mann-Whitney (U) was used. For the statistical data, in some cases the $\div 2$ test was used. The threshold of significance for the used tests were $\alpha=0.05$ (5%), $\alpha=0.01$ (1%) or $\alpha=0.001$. To find the correlation between two variables the Pearson (r) or Spearman (ρ) correlation coefficient was used. The Colton rule was applied to analyze the correlation coefficient. The preworked statistical data was effectuated through the StatsDirect v.2.7.2 program, with OpenEpi v.3.03 application and Excel (from Microsoft Office 2010 package). A graphic representation of the results was made in Excel (from Microsoft Office 2010 package).

Results and discussions

Table 1 present the comparative analysis of determined *p*H values of oral fluid in the studied children patients.

Table 1

COMPARATIVE ANALYSIS OF DETERMINED pH VALUES IN THE STUDIED PATIENTS

Groups		pH average	Minimum value of pH	Maximum value of pH
6-8 years old	*Total*	5.45	5.2	5.7
	Male	5.3	5.2	5.4
	Female	5.8	5.4	6.2
9-12 years old	*Total*	5.65	5.4	5.9
	Male	5.5	5.2	5.8
	Female	6.0	5.6	6.4

The determined values of oral fluid *p*H was between 5.2 and 6.4. We found differences in *p*H values both in the investigated groups and subgroups. The found differences between the two groups was of 0.2 units, and between subgroups of 0.2 units too. We found that in both groups, the subgroup *male* showed more acidic *p*H values of the oral fluid compared to the *female* group, and the differences found were 0.5 units in both age groups. These differences between subgroups are due to the care of female children for their aesthetic appearance.

Table 2 present the comparative analysis used for the *defs* values in the studied groups and subgroups, and their statistical significance. At the statistical analysis of the *defs* values, taking into consideration all of the subgroups, there was observed an intense significant statistical difference between at least two values ($p < 0.001$). During the statistical analysis of the *defs* values for the unpaired probe, the following was observed: a. Intense significant statistical difference between the groups of 6-8 years old vs. 9-12 years old ($p < 0.001$); b. A very significant statistical difference between the subgroups of 9-12 years old, male vs. female ($p < 0.01$); c. Intense significant statistical difference between the subgroups of males, 6-8 years old vs 9-12 years old ($p < 0.001$) and the female subgroups, 6-8 years old vs. 9-12 years old ($p < 0.001$).

At the statistical analysis of the *deft* values, taking into consideration all of the subgroups, there was observed an intense significant statistical difference between at least two values ($p < 0.001$). During the statistical analysis of the *deft* values for the unpaired probe, the following was

Table 2

COMPARATIVE ANALYSIS FOR THE DEFS VALUES FOR GROUPS/SUBGROUPS STUDIED AND THE STATISTICAL SIGNIFICANCE

Groups		Average	ES	Median	DS	Min	Max	*Statistical significance (p)*		
6-8 years old	*Total*	7.68	0.2894	6	7.6618	0	41	All subgroups		3.69×10^{-45}
	Male	7.49	0.3950	6	7.4204	0	41	6-8 years old vs 9-12 years old		7.37×10^{-24}
	Female	7.88	0.4237	6	7.9047	0	40	Male vs Female	6-8 years old	0.4956
9-12 years old	*Total*	4.14	0.1875	2	5.2568	0	38		9-12 years old	0.0055
	Male	4.60	0.2837	3	5.8555	0	38	6-8 years old vs 9-12 years old	Male	4.86×10^{-9}
	Female	3.58	0.2314	2	4.3896	0	30		Female	8.24×10^{-18}

observed: a. Intense significant statistical difference between the groups of 6-8 years old vs. 9-12 years old ($p < 0.001$); b. Intense significant statistical difference between the subgroups of males, 6-8 years old vs 9-12 years old ($p < 0.001$) and the female subgroups, 6-8 years old vs. 9-12 years old ($p < 0.001$). A comparative analysis used for the *deft* values of the study groups/subgroups and the statistical significance is presented in table 3.

At the statistical analysis of the *dmfs* values, taking into consideration all of the subgroups, there was observed an intense significant statistical difference between at least two values ($p < 0.001$). During the statistical analysis of the *dmfs* values for the unpaired probe, the following was observed: a. Intense significant statistical difference between the groups of 6-8 years old vs. 9-12 years old ($p < 0.001$); b. Intense significant statistical difference between the subgroups of males, 6-8 years old vs 9-12 years old ($p < 0.001$) and the female subgroups, 6-8 years old vs. 9-12 years old ($p < 0.001$). A comparative analysis used for the *dmfs* values of the study groups/subgroups and the statistical significance is presented in table 4.

At the statistical analysis of the *dmft* values, taking into consideration all of the subgroups, there was observed an intense significant statistical difference between at least two values ($p < 0.001$). During the statistical analysis of the *dmft* values for the unpaired probe, the following was observed: a. Intense significant statistical difference between the groups of 6-8 years old vs. 9-12 years old ($p < 0.001$); b. Intense significant statistical difference between the subgroups of males, 6-8 years old vs 9-12 years old ($p < 0.001$) and the female subgroups, 6-8 years old vs. 9-12 years old ($p < 0.001$). A comparative analysis used for the *dmft* values of the study groups/subgroups and the statistical significance is presented in table 5.

The study demonstrated the direct conditionality between the *p*H of the oral fluid and the epidemiologic indicators of dental caries that affect the deciduous and the permanent molars in the children aged within 6-12 years. Values of measured *p*H in the oral fluids were more acid in the children's with a higher rate of dental caries (*p*H values between 5.2-5.4) and more increased in the children's oral cavity with lower rate of dental caries (6.2-6.4). In conformity with the research results, it was found that 72% of the children included into the study group presented with at least a dental surface of affected deciduous teeth, while only 40% of the children presented a carious process on their permanent teeth. The dental surfaces that were most frequently affected by one cavity was the occlusal surface, both in deciduous dentition, as well as in mixed dentition, followed by the mesial/distal surface and last being situated on the oral and vestibular surfaces. The DMFT average in this study was after gender, of 1.39 for female children and of 1.22 for male children with age between 9-12 years. These interval of values were found to be the wanted and established from the World Health Organization too.The statistical analysis of the values of the studied indices, taking into consideration all of the subgroups, presented an intense significant statistical difference between at least two values ($p < 0.001$).

Majority of researches studies looked towards the caries model based on dental evaluation that conforms to the DMFT index [12,14]. A study realized by Schapira about the prevalence of caries on the first permanent molar revealed the following percentages: 57% up to the age of 6.84% from 6-12 years old and 89% after the age of 12 [15]. The study effectuated in 2003, Tarmure [16] determined the frequency of dental caries in the children between the ages of 6-12 years from 3 cities in Transilvania and founded the following percentages: Cluj-Napoca =84%, Bistrita=86%, Baia Mare=89%. Prevalence of class I dental caries on first permanent molars affecting the children of Cluj-Napoca in 2008 were 88%. Honcala et al [17] analyzed the correlation and distribution of caries on the deciduous and permanent molars in conformity with

Table 3

COMPARATIVE ANALYSIS FOR THE **DEFT** VALUES FOR GROUPS/SUBGROUPS STUDIED AND THE STATISTICAL SIGNIFICANCE

Groups		Average	ES	Median	DS	Min	Max	*Statistical significance (p)*		
6-8 years old	*Total*	4.00	0.1197	4	3.1688	0	16	All subgroups		2.26×10^{-57}
	Male	3.89	0.1648	4	3.0967	0	12	6-8 years old vs 9-12 years old		2.66×10^{-30}
	Female	4.12	0.1737	4	3.2405	0	16	Male vs Female	6-8 years old	0.3229
9-12 years old	*Total*	2.28	0.0850	2	2.3833	0	20		9-12 years old	0.0761
	Male	2.42	0.1238	2	2.5556	0	20	6-8 years old vs 9-12 years old	Male	2.69×10^{-12}
	Female	2.12	0.1135	2	2.1541	0	12		Female	1.31×10^{-20}

Table 4

COMPARATIVE ANALYSIS FOR THE **DMFS** VALUES FOR GROUPS/SUBGROUPS STUDIED AND THE STATISTICAL SIGNIFICANCE

Groups		Average	ES	Median	DS	Min	Max	*Statistical significance (p)*		
6-8 years old	*Total*	0.82	0.0635	0	1.6807	0	18	All subgroups		3.14×10^{-21}
	Male	0.75	0.0783	0	1.4709	0	10	6-8 years old vs 9-12 years old		1.5×10^{-13}
	Female	0.89	0.1002	0	1.8694	0	18	Male vs Female	6-8 years old	0.2910
9-12 years old	*Total*	1.62	0.0865	1	2.4257	0	15		9-12 years old	0.8245
	Male	1.64	0.1185	1	2.4458	0	15	6-8 years old vs 9-12 years old	Male	7.92×10^{-10}
	Female	1.60	0.1268	0	2.4050	0	15		Female	1.21×10^{-5}

Table 5

COMPARATIVE ANALYSIS FOR THE **DMFT** VALUES FOR GROUPS/SUBGROUPS STUDIED AND THE STATISTICAL SIGNIFICANCE

Groups		Average	ES	Median	DS	Min	Max	*Statistical significance (p)*		
6-8 years old	*Total*	0.69	0.0454	0	1.2015	0	6	All subgroups		3.54×10^{-24}
	Male	0.67	0.0649	0	1.2196	0	6	6-8 years old vs 9-12 years old		4.76×10^{-15}
	Female	0.70	0.0635	0	1.1846	0	4	Male vs Female	6-8 years old	0.7669
9-12 years old	*Total*	1.30	0.0618	0.5	1.7337	0	11		9-12 years old	0.2749
	Male	1.36	0.0873	1	1.8018	0	11	6-8 years old vs 9-12 years old	Male	5.92×10^{-10}
	Female	1.22	0.0869	0	1.6490	0	10		Female	1.61×10^{-6}

the ICDAS index and founded that there exists no report that has a caries model that covers the full spectrum of this affection. Also, founded epidemiological indicators for dental caries that involve the first permanent molars in this study confirm what was written in the research of Honcala et al [17]. The authors evaluated the first molar teeth with the ICDAS criteria in Estonian children aged between 7 and 8 years. Enamel lesions that were visible on teeth when they were wet (Cod ICDAS 2), situated on the occlusal surface of the first permanent molars (up to 17% of the teeth) were the most spread in their study.

Saliva plays a critical role in the homeostasis of the oral cavity through its multiple functions: protection against viral, bacterial and fungal infections, repairing oral mucosa, buffering capacity and remineralizing of teeth by providing Ca+ and phosphate ions [1,18]. As other body biological fluids (blood, lympha), saliva is a biomarker used in the assessment of various pathological conditions of human organism [2]. The researches of Bud et al [19] about the interrelation between salivary *p*H, buffer capacity and dental caries in underweight, normal weight and overweight children showed that underweight children from our study group tend to have a medium buffer capacity and a significantly lower *p*H.

The first permanent molar present a major importance in the development of human permanent dentition and this is the reason that special accent should be laid in the preventive education. So, the patients will come to the dentist's prior the apparition of the dental caries, when is possible to be realized adequate prevention measures and of early diagnosis, with the application of modern methods and means in incipient stages of lesions.

Conclusions

The study demonstrated the correlation between the *p*H of oral fluid and the epidemiologic indicators of dental caries that affect deciduous and permanent teeth in the study group of children aged between 6-12 years.

The age interval 6-12 year is very important for the maintenance of a good health oral status and the most optimal for the initiation of dental caries prophylaxis and of orthodontic treatments.

Implementation of prevention measures can stop the apparition of cavitary process and invasive and expensive treatments will be avoids.

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