



ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Caries risk assessment in pregnant women using Cariogram

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SUMMARY

Introduction/Objective "Cariogram" takes into account interactions between caries-related factors and expresses a graphic assessment of the caries risk.

The aim of this study was to evaluate the relationship between caries risk and different variables of Cariogram in pregnant women.

Methods This study included 96 pregnant women. At baseline, data on general health, diet, oral hygiene, and fluoride exposure were obtained. DMFT (decayed, missing, and filled teeth) index was calculated by clinical examination. Saliva analyses included mutans streptococci and lactobacilli counts, buffer capacity, and secretion rate. Scores were entered and caries risk was assessed. The women were divided into five groups according to their Cariogram caries risk.

Results The results of the study showed that 29.17% (28) of the pregnant women had high caries risk, 21.88% (21) – medium, 17.71% (17) – low, 16.67% (16) – very high, and 14.58% (14) – very low caries risk. In an average caries risk profile of pregnant women, the dominant sector was "Bacteria" (18.85% of the risk structure profile), followed by "Diet" (17.97%), "Circumstances" (15.68%), and "Susceptibility" sector (14.65%).

Conclusion Cariogram shows that pregnant women in Banja Luka, Bosnia and Herzegovina, had 46.14% chance of avoiding caries in the future. The Cariogram model can successfully determine caries risk profiles for pregnant women.

Keywords: Cariogram; caries risk assessment; mutans streptococci; pregnant women

INTRODUCTION

Caries risk is the probability of a person to develop least certain sign of caries, reaching a given stage of the disease progression for specific period of time, on condition that the exposure to caries risk factors remains unchangeable during the period. Caries management by risk assessment is granted considerable attention [1–4].

In a view of the multifactorial nature of caries etiology and the fact that the course of the disease is determined by permutations and combinations of causal factors [1–4], the challenge is to develop a really effective model for predicting caries risk. Cariogram, a computer program, assesses an individual's caries risk profile and illustrates it graphically. Also, Cariogram offers recommendations for targeted preventive measures that should be implemented to avoid the formation of new caries lesions [5–9]. Cariogram has been used to assess the caries risk profile of schoolchildren, teenagers, orthodontic, and elderly patients [7, 10–14].

The aim of this study was to assess caries risk in pregnant women in Banja Luka, Bosnia and Herzegovina, and to evaluate the contribution of various risk factors among different caries risk groups.

METHODS

The study was conducted as a cross sectional study on a sample of 96 pregnant women from Banja Luka, Republic of Srpska, Bosnia and Herzegovina. The study sample was randomly selected and included only pregnant women who were a) in the last trimester of pregnancy, b) without risk in pregnancy, c) did not have any chronic disease, d) had not taken antibiotics or other drugs during pregnancy, e) signed an informed consent to participate in the research. The average age of the pregnant women was 27.4 years, ranging between 20 and 42. Ethical approval for the study was obtained from the Research Committee of the Faculty of Medicine, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina. The research has been conducted in full accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study included a questionnaire, interview, clinical examination, saliva sampling, and assess of caries risk using Cariogram. Each of the patients completed a brief questionnaire on their general health, oral hygiene, dietary behavior, frequency of tooth brushing, the use of fluoridated toothpaste, and mouthwashes.

Примљено • Received:

February 9, 2016

Прихваћено • Accepted:

November 8, 2016

Online first: February 28, 2017

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The clinical examination comprised the DMFT (decayed, missing, and filled teeth) index and oral hygiene status. Clinical examinations were carried out in the morning, between meals by the same examiner following the WHO criteria [15]. Clearly visible lesions with cavities on tooth surfaces were classified as dental caries (i.e. d3-level cavities), whereas changes in transparency, initial enamel demineralization with intact surfaces and no cavitations were noted as intact teeth. The teeth were not professionally cleaned and no radiographs were taken. The patients did not take any food or drink (except water), did not wash their teeth, or chew gum at least one hour before the exam and saliva sampling. The plaque index was also evaluated, using Silness and Løe's scale. Plaque was assessed through collection from vestibular surfaces.

After the clinical examinations, the saliva tests (secretion rate, saliva's buffer capacity, *Lactobacillus* and mutans streptococci counts) were performed. All saliva tests were obtained from Orion Diagnostica, Espoo, Finland, and handled according to the instructions of the manufacturer. The patient chewed a sterile paraffin pellet for five minutes. The stimulated saliva was collected in a test tube graduated in milliliters, then the volume of stimulated whole saliva was read off and the result was expressed in ml/min. Buffer capacity was categorized as high, medium, or low using a Dentobuff® Strip (Orion Diagnostica). The salivary

Streptococcus mutans were made with Dentocult® SM-Strip Mutans (Orion Diagnostica) by placing the vial with the sample carrier in an incubator at 37°C for 48 hours. For measuring *Lactobacillus* count, Dentocult LB® (Orion Diagnostica) was used, by placing the vial with the sample carrier in an incubator at 37°C for 96 hours. The density of colonies (*Streptococcus mutans* and *Lactobacillus*) was compared with a chart provided by the manufacturer.

The data from the clinical examinations and the questionnaire were entered into the Cariogram model. To create an individual risk profile, nine factors/variables are required to be entered into the Cariogram (Table 1). The Cariogram calculated the data and presented the result expressed as a pie chart, illustrating the "Chance of avoiding cavities" in the future. Sectors of the diagram are as follows: "Bacteria" (plaque amount and mutans streptococci level), "Diet" (*Lactobacillus* level and diet frequency), "Susceptibility" (fluoride program, saliva secretion, and saliva buffer capacity), and "Circumstances" (past caries experience and medical history) [16]. The chance to avoid caries was finally grouped in five risk categories: very low risk = 81–100% chance of avoiding caries, low risk = 61–80% chance of avoiding caries, medium risk = 41–60% chance of avoiding caries, high risk = 21–40% chance of avoiding caries, very high risk = 0–20% of avoiding caries.

Table 1. Caries related factors/parameters used at baseline for the Cariogram*

Factor	Information and data collected	Cariogram scores
Caries experience	Past caries experience at baseline, including cavities, fillings, and missing teeth due to caries	0: caries free 1: better than normal condition for ages 2: normal condition for ages 3: worse than normal condition for ages
Related diseases	General diseases or conditions associated with dental caries; medical history, medications; data from interviews and questionnaire results	0: no disease, healthy 1: general disease which can indirectly influence the caries process to a mild degree 2: general disease which can indirectly influence the caries process to a high degree
Diet, contents	<i>Lactobacillus</i> counts were used as a measure of cariogenic diet, using Dentocult test	0: <10 ³ CFU/ml 1: 10 ⁴ –10 ⁵ CFU/ml 2: 10 ⁵ CFU/ml 3: >10 ⁶ CFU/ml
Diet, frequency	Estimation of number of meals and snacks per day, mean for "normal days;" data from questionnaire results	0: maximum 3 meals per day 1: 4–5 meals per day 2: 6–7 meals per day 3: > 7 meals per day
Plaque amount	Estimation of hygiene according to Silness–Løe plaque index	0: PI < 0.4 (very good oral hygiene) 1: PI = 0.4–1.0 (good oral hygiene) 2: PI = 1.1–2.0 (poor oral hygiene) 3: PI > 2 (very poor oral hygiene)
<i>Mutans streptococci</i>	Estimation of levels of <i>Mutans streptococci</i> in saliva, using Strip mutans test (Dentocult)	0: < 10 ⁴ /ml 1: 10 ⁴ – 10 ⁵ /ml 2: 10 ⁵ – 10 ⁶ /ml 3: > 10 ⁶ /ml
Fluoride program	Estimation of the extent of fluoride available in the oral cavity	0: maximum fluoride program 1: fluoride supplements 2: only fluoride toothpaste
Saliva secretion	Estimation of flow rate of paraffin-stimulated saliva	0: > 0.7 ml/min. 1: 0.3–0.7 ml/min. 2: < 0.3 ml/min.
Saliva buffering capacity	Estimation of capacity of saliva to buffer acids, using Dentobuff test	0: pH > 5.5 (blue) 1: pH = 4.5–5.5 (green) 2: pH < 4.5 (yellow)

PI – Silness–Løe plaque index

* Taken from Caries Risk Evaluation, Department of Cariology, Malmö University

Statistics

All data were processed with the SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA) χ^2 test of contingency was used to compare differences between groups. Parametric ANOVA and Student's t-test for independent samples (if the difference variance observed characteristics were not statistically significant) and nonparametric Mann–Whitney test (if the difference in variance of the observed characteristics is statistically significant) were used to compare the mean values of the characteristics. P-values less than 0.05 were considered statistically significant.

RESULTS

The results of the study showed that 16 (16.67%) pregnant women had very high caries risk, 28 (29.17%) high, 21 (21.88%) medium, 17 (17.71%) low, and 14 (14.58%) had very low caries risk (Table 2).

Table 2 shows the odds ratios for different Cariogram groups. Pregnant women in the low risk group had a risk 1.2 times higher than that of pregnant women in the very low risk group. In the groups with a medium, high and very high risk, the corresponding values were 4.9, 7.0 and 7.7 times higher, respectively. These results are statistically significant.

In an average caries risk profile of pregnant women, the dominant sector was “Bacteria” (data about plaque amount and mutans streptococci level), with 18.85% of the risk structure profile. It was followed by “Diet” (data about *Lactobacillus* level and diet frequency) with 17.97%.

Table 2. Odds ratio values for different Cariogram groups in the logistic regression model

Caries risk assessed by Cariogram	Pregnant women		OR	95% CI	p-value*
	n	%			
Very high risk	16	16.67	7.7	1.16–51.17	0.020
High risk	28	29.17	7	1.45–33.7	
Medium risk	21	21.88	4.9	0.99–24.21	
Low risk	17	17.71	1.2	0.25–5.84	
Very low risk (reference value)	14	14.58	1		
Σ	96	100			

“Circumstances” sector (data about caries experience and medical history) was present with 15.68% in the Cariogram profile, and “Susceptibility” sector (data about fluoride program, saliva secretion, and buffering capacity) was present with 14.65%. In the groups of subjects with high and medium risk, the dominant sector was also “Bacteria” with 24.14% and 18.05%, respectively, followed by “Diet” (20.93% and 15.71%, respectively), “Circumstances” (16.79% and 15.19%, respectively) and “Susceptibility” (16.61% and 13.52%, respectively). In the group of pregnant women very high risk, the dominant sector was “Diet” (31.13%), followed by “Bacteria” (26.88%), “Susceptibility” (21.63%), and “Circumstances” (20.13%). In the groups of subjects with low and very low risk, the dominant sector was “Circumstances” (13.71% and 11.50%, respectively), than “Diet” (9.18% and 4.14%, respectively), “Susceptibility” (9% and 3%, respectively) and “Bacteria” (6.94% and 4.50%, respectively), as shown in Table 3.

The comparative assessment of study participants based on parameters used in the Cariogram model is shown in Table 4. The distribution of the patients within each Cariogram variable was significantly different ($p < 0.01$) for all factors considered. Majority of the participants (56.25%) in this study had caries experience worse than normal condition for ages. All participants in the group with the very high risk of caries had the highest *Lactobacillus* count (more than 10^6 CFU/ml), very high *Streptococcus mutans* count (more than 10^5 CFU/ml) and more than six meals per day. The maximum number of pregnant women with very low caries risk had very good and good oral hygiene (plaque index ≤ 1). Most of the pregnant women in all groups of risk were exposed to fluoride in the form of toothpastes only. The results show that most of the pregnant women (87.5%) had normal amount of saliva secretion (> 0.7 ml/min.). All pregnant women in the group of very low risk showed saliva secretion to be less than 0.5 ml/min. All of the participants in the group of very high risk had saliva pH of less than 4.5.

DISCUSSION

Over the past several decades, researchers have been looking for factors such as host, diet, microflora, past caries

Table 3. The average Cariograms of pregnant women

Sectors in Cariogram	Σ	Very high risk		High risk		Medium risk		Low risk		Very low risk	
		X	SD	X	SD	X	SD	X	SD	X	SD
Chance to avoid caries	46.14	9.88	2.36	27.86	5.95	46.43	5.13	71.06	5.84	93.43	6.42
Diet	17.97	31.13	1.71	20.93	5.13	15.71	3.68	9.18	1.47	4.14	1.68
Bacteria	18.85	26.88	3.4	24.14	3.01	18.05	3.57	6.94	3.07	4.5	1.29
Susceptibility	14.65	21.63	3.48	16.61	4.67	13.52	2.46	9	2.06	3	0.82
Circumstances	15.68	20.13	0.25	16.79	1.73	15.19	2.52	13.71	1.95	11.5	0.58

\bar{x} – mean value

Table 4. Comparison of caries-related factors between groups of pregnant women

Factor	Score	Risk									
		Very high		High		Medium		Low		Very low	
		n	%	n	%	n	%	n	%	n	%
Caries experience	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	9	34.62	9	34.62	8	30.77
	2	0	0	3	18.75	3	18.75	4	25	6	37.5
	3	16	29.63	25	46.3	9	16.67	4	7.41	0	0
	p-value	< 0.001									
Diet, contents	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	13	100
	2	0	0	26	41.27	19	30.16	17	26.98	1	1.59
	3	16	80	2	10	2	10	0	0	0	0
	p-value	< 0.001									
Diet, frequency	0	0	0	2	10.53	0	0	12	63.16	5	26.32
	1	0	0	18	35.29	19	37.25	5	9.8	9	17.65
	2	2	16.67	8	66.67	2	16.67	0	0	0	0
	3	14	100	0	0	0	0	0	0	0	0
	p-value	< 0.001									
Plaque amount	0	0	0	0	0	0	0	7	38.89	11	61.11
	1	0	0	2	11.76	4	23.53	8	47.06	3	17.65
	2	10	21.28	21	44.68	14	29.79	2	4.26	0	0
	3	6	42.86	5	35.71	3	21.43	0	0	0	0
	p-value	< 0.001									
<i>Streptococcus mutans</i>	0	0	0	0	0	0	0	0	0	5	100
	1	0	0	0	0	5	16.13	17	54.84	9	29.03
	2	2	4.55	26	59.09	16	36.36	0	0	0	0
	3	14	87.5	2	12.5	0	0	0	0	0	0
	p-value	< 0.001									
Fluoride programme	0	0	0	0	0	0	0	0	0	0	0
	1	2	8.00	2	8	8	32	2	8	11	44
	2	14	20.59	26	38.24	13	19.12	15	22.06	0	0
	p-value	< 0.001									
Saliva secretion	0	12	14.29	25	29.76	19	22.62	14	16.67	14	16.67
	1	4	33.33	3	25	2	16.67	3	25.00	0	0
	2	0	0	0	0	0	0	0	0	0	0
	p-value	< 0.001									
Saliva buffering capacity	0	0	0	11	27.5	6	15	15	37.5	8	20
	1	0	0	9	39.13	7	30.43	1	4.35	6	26.09
	2	16	48.48	8	24.24	8	24.24	1	3.03	0	0
	p-value	< 0.001									

*p < 0.05, statistically significant

history, which would enable them to predict who would develop a carious lesion. An innovation in caries risk assessment has been the development of a computer program called Cariogram, which compared caries experience, related general diseases, diet content, diet frequency, amount of plaque, mutans streptococci counts, fluoride program, saliva secretion rate, saliva buffering capacity. This program is a prediction and a risk model, as it predicts who has a chance to develop the disease, identifies the risk factors, and based on that determines the appropriate intervention plan [16].

In previous studies, caries risk was assessed with Cariogram for different individuals of various communities, and different results were reported [12, 13, 17, 18, 19]. There is

no data about caries risk assessments in pregnant women using Cariogram. Also, there is insufficient data about caries risk assessment in the population of Bosnia and Herzegovina. The present study is the first one where Cariogram has been applied on pregnant women for caries risk assessment.

In the present study, the majority of participants were at high risk of caries according to Cariogram. The number of patients in the very high caries risk group was found to be the highest in the Swedish elderly (55–75 years old) who had histories of multiple drug use and had no access to effective fluoride programs before the 1960s [14]. Another study performed in adults with several dental restorations in Saudi Arabia reported that the majority of participants had a high risk of caries [19]. Gökalp et al. [20] reported

that the prevalence rates of caries in children and adult populations in Turkey were high.

On the other hand, the number of patients in a low caries risk group was found to be the highest in Spanish dental students (18–19 years old) [17]. Celik et al. [21] reported that the number of Turkish adults (20–21 years old) had medium (33%) or low (24%) caries risk. Studies concerning Sardinian (7–9 years old) and Swedish (10–11 years old) schoolchildren also reported the highest number of patients in a low caries risk group [12, 22].

According to the 'opinion' of the Cariogram, the Laotian children (12–13 years old) demonstrated significantly higher caries risk than Swedish children. The average "chances of avoiding caries in the future" in the groups of Swedish and Laotian children were 69.2% and 37.3%, respectively [23].

The leading sector in pregnant women risk profile in this study was "Bacteria" (18.85%), followed by "Diet" (17.97%). A study in Sweden reported similar results [24]. Comparison of these results with those of Petersson et al. [24] showed that the leading sectors in Swedish children Cariogram were also "Bacteria" (9%) and "Diet" (8%). "Susceptibility" and "Diet" factors (23% and 20%, respectively) ranked first in the group of dental students (18–25 years old) from Minsk, Belarus [25]. The "Bacteria" factor was the most dominant sector for students in Valencia [17].

In this study, for all groups of participants, statistically significant correlations were found between the "frequency of food intake" and the risk of caries. If the frequency of food intake was higher, the risk was higher. Even 100% of pregnant women who consumed more than seven meals per day were in a group of very high risk. Petersson et al. [10] also confirmed that the frequency of food intake has a very important role in the risk assessment of Swedish children, especially for a high risk group.

In the present study a statistically significant correlation was found between caries risk and concentration of *Streptococcus mutans* in saliva. Other studies that used

Cariogram for risk assessment in the Swedish elderly and children aged 10–11 years reported similar results. The largest increase in caries had over 60% of elderly who had more than 10^5 CFU/ml of saliva. As much as 94.5% of children (aged 10–11 years) who had more than 10^5 CFU/ml saliva were at high risk [7, 14]. Günay et al. [26] reported in their study that 68.5% of pregnant women and 61.5% of children aged three years had concentrations of more than 10^5 CFU/ml of saliva. According to Köhler et al. [27], 80% of new mothers had concentrations of more than 10^5 CFU/ml of saliva. About 50% of tested pregnant women and young mothers had concentrations of more than 10^6 CFU/ml in saliva in researches in Finland [28, 29].

CONCLUSION

This study was performed with Cariogram in pregnant women in an effort to overcome data insufficiency of caries risk assessments in Bosnian populations. Cariogram shows that pregnant women in Banja Luka, Bosnia and Herzegovina, had a high risk of developing new caries lesions, with a 46.14% chance of avoiding caries in the future. The main risk Cariogram sectors were "Bacteria" and "Diet." The Cariogram model can successfully determine caries risk profiles for pregnant women. Further longitudinal studies in Bosnian populations are needed to assess caries risk in various age and risk groups.

ACKNOWLEDGMENTS

This research was supported by the Ministry of Science and Technology of the Republic of Srpska, Bosnia and Herzegovina. Also, we are grateful to Orion Diagnostica, Finland, for making this research possible, and to Bojan Stanković for statistical analysis.

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Процена ризика од каријеса код трудница употребом Кариограма

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САЖЕТАК

Увод/Циљ Кариограм програм процењује и графички илуструје ризик од каријеса узимајући у обзир интеракцију различитих фактора његовог настанка.

Циљ рада је био да се процени однос ризика од каријеса и разних параметара Кариограм програма код трудница.

Методe У студију је укључено 96 трудница. Узети су подаци о општем здрављу, исхрани, оралној хигијени и употреби флуорида. Након клиничког прегледа израчунат је КЕП (кариозни, естраховани и пломбирани зуби) индекс. Анализом пљувачке добијени су подаци о количини стимулисане пљувачке, пуферском капацитету пљувачке, степену колонизације *Streptococcus mutans*-а и лактобацила. Подаци су унесени у Кариограм програм и процењен је

ризик од каријеса. Труднице су подељене у пет група по кариограму.

Резултати Са високим ризиком од каријеса је 29,17% (28) трудница, 21,88% (21) – са средњим, 17,71% (17) – ниским, 16,67% (16) – врло високим, а 14,58% (14) – врло ниским ризиком од каријеса. У просечном ризику од каријеса доминантан сектор је сектор „Бактерије“ (18,85%), следе „Исхрана“ (17,97%), „Околности“ (15,68%) и „Осетљивост“ (14,65%).

Закључак Кариограм програм је показао да су труднице у Бањој Луци имале 46,14% „шансе за избегавање каријеса у будућности“. Кариограм модел може успешно одредити профил ризика од каријера за труднице.

Кључне речи: Кариограм; процена ризика од каријеса; *Streptococcus mutans*; труднице