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Risk profile of adults with several dental restorations using the Cariogram model

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Abstract

Objective. The aims of the study were: 1) to evaluate the caries profile in a group of Saudi adults with several dental restorations by assessing various caries-related factors using the Cariogram model, and 2) to correlate the Cariogram data, expressed as "the chance of avoiding caries", with initial caries lesions (DiS), total initial and manifest caries lesions (Di+mS), and filled surfaces (FS). ***Material and Methods.*** 175 individuals in Saudi Arabia, aged between 18 and 56 years, were included. All were interviewed about their oral health, dietary habits, and use of fluoride, and were examined for dental caries, both clinically and radiographically. Salivary and microbiological factors, including the number of mutans streptococci and lactobacilli, buffer capacity, and secretion rate, were obtained using chair-side tests. ***Results.*** The number of teeth, total Di+mMFS, Di+mS, and FS were 26.0, 53.8, 19.3, and 22.6, respectively. The mean chance of avoiding caries was 31% $\pm$19.7. The individuals were divided according to Cariogram data "the chance of avoiding caries" into four risk groups: 0–20% ($n=66$) "high-risk", 21–40% ($n=43$) "medium-risk", 41–60% ($n=50$) "low-risk", and 61–100% ($n=16$) "very low-risk". ANOVA revealed statistically significant differences between the high-risk group and the other three groups with respect to Di+mS ($p<0.01$) and FS ($p<0.05$). The mean DiS of the high-risk group differed significantly from that of the low-risk group ($p<0.05$). ***Conclusions.*** The Cariogram model can identify the caries-related factors that could be the reasons for the estimated future caries risk. There is a direct association between the categorized outcomes of the Cariograms and the DiS and Di+mS indices.

Key Words: *Adults, caries risk, Cariogram, dental restorations, Saudi Arabia*

Introduction

The presence of several restored tooth surfaces in a patient may reflect a high level of caries activity. However, many adults, particularly women, usually display more interest in seeking dental treatment than teenagers do, which may result in over-treatment [1]. This is probably the case in developed countries as a result of the well-established dental care services and availability of various dental insurance systems. In developing countries like Saudi Arabia, the prevalence of dental caries is high compared with that of many other countries. For example, the mean DMFT of 12 to 14-year-olds has been reported to be 5.9 [2], while the corresponding value in 35 to 44-year-olds is around 9, according to the World Health Organization (WHO). In countries with an established market economy, the DMFT of 12-year-olds is approximately 1 [3]. In overall terms, young adults with multiple dental restorations in a country of this kind would be regarded as high-risk patients, their caries status needing to be evaluated regularly in order to prevent further restorations.

There is no single test that can accurately predict an individual's susceptibility to caries [4]. Caries is a multifactorial disease including caries experience, use of fluoride, presence of plaque, dietary habits, number of cariogenic bacteria, and salivary factors, as well as social and behavioral factors. Caries assessment is therefore a complex process and the results so far are not encouraging, not even in young adults [5]. Against this background, a computer-based program (Cariogram) has been developed for caries assessment [6]. The data show a significant correlation between the Cariogram results and the caries increment over time for both children and adults [7,8].

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The aims of the present study were: 1) to evaluate the caries profile in a group of Saudi adults with several dental restorations by assessing various caries-related factors using the Cariogram model; and (2) to correlate the Cariogram data, expressed as "the chance of avoiding caries", with initial (non-cavitated) caries lesions (DiS), total initial and manifest (cavitated) caries lesions (Di+mS), and filled surfaces (FS).

Material and methods

Population

A total of 175 adult Saudi patients out of 511 had accepted to be involved in the study, their ages ranging from 18 to 56 years (mean age 29.5 years); 71% F ($n=125$), 29% M ($n=50$). The inclusion criteria were: 1) at least 20 teeth present and 2) a minimum of 7 teeth with dental restorations (amalgams, composites, glass ionomers, and crowns). The individuals were randomly selected from a Dental Health Clinic of Internal Security at Makkah and from the Emergency Dental Department at the Faculty of Dentistry, King Abdulaziz University in Jeddah, Saudi Arabia. Informed consent was obtained prior to the start of the examination. The local ethics committee approved the study (code number 29/1/1419).

Caries registration

The clinical examination was carried out by one of the authors (H.S.) using magnification glasses (2.5 ×) and a dental mirror, and with the patient seated in a dental chair under optimal light. Before caries registration, but after plaque scoring, the teeth were cleaned with a rubber cup and pumice, flossed, and then dried with compressed air. Dental caries was recorded according to the criteria of the WHO [9]. The numbers of manifest (m) caries lesions (Dm), missing (M), and filled (F) tooth surfaces (S) were scored for each individual and calculated as DmMFS. Molars and premolars were considered to have five surfaces and incisors and canines four. A tooth surface with both caries and a restoration was regarded as a carious surface. A crowned tooth was scored as 5 FS. Third molars were excluded from the registration. Tooth surfaces with initial (i) caries lesions (DiS) were registered separately, included in the component Di+mS and added to DmMFS, resulting in a total number of Di+mMFS.

Radiographic recording

Four bitewing radiographs were taken for each patient by a dental assistant. Approximal caries was scored using a 6-grade scale (0 to 5) according to Gröndahl et al. [10] and illustrated by Mejàre et al. [11]. Approximal restorations, missing and unreadable surfaces (overlapped or questionable) were scored as 6, 7, and 8, respectively. Recurrent caries or any radiolucency at the approximal gingival margin of the restoration was scored as 9. A total of 680 bitewing radiographs were evaluated by one examiner (H.S.) using a light desk and a magnifying viewer [12]. All approximal surfaces from the distal surface of the 1st premolar to the mesial surface of the 2nd molars were included, making a total of 24 surfaces. Scores of 1–5 were added to the Di+mS index, apart from scores of 4 and 5 in teeth that had already been registered as clinically decayed to avoid double registration.

Caries risk profile

The Cariogram program, with a built-in algorithm, evaluates the caries risk profile of an individual [6]. Nine factors of relevance to caries are entered into the program and given a score according to predetermined scales for each factor (Table I). For all individuals in the present study, "caries experience" was given a score of 3, which states for (worse status than normal for age group), and the "clinical judgment" factor was given a score of 1, which means that the risk is evaluated according to the other values entered. The main result of the Cariogram is expressed as "the chance of avoiding caries" (green sector), which was used here for further analysis. The 175 individuals were divided into four risk groups according to the "percentage chance of avoiding caries": 1) 0–20% (here called "high risk"), 2) 21–40% (here called "medium risk"), 3) 41–60% (here called "low risk"), and 4) 61–100% (here called "very low risk"). The numbers of individuals in each group were 66, 43, 50, and 16, respectively.

Questionnaire

All the patients were interviewed using a standardized structured questionnaire according to the Cariogram manual [13] to elicit information about medical and dental history, dietary habits, and the use of fluoride dentifrices, mouth rinse solutions, and tablets.

Plaque index

Before professional cleaning and saliva sampling, the plaque index (PI) was recorded according to Silness & Löe [14]. Four tooth surfaces were examined for the following six teeth: 16, 12, 24, 36, 32, and 44. The neighboring tooth was recorded if one of the first six was missing.

Salivary and microbiological factors

Paraffin-stimulated saliva was collected for 5 min and the salivary secretion rate was expressed as ml/min.

Table I. Frequency (*n*) of some caries-related factors according to the Cariogram score for the total of 175 individuals and for each risk group with respect to the percentage chance of avoiding caries (green sector).

Caries-related factors	Cariogram scores	Risk goups				
		0–20% ($n=66$)	21–40% ($n=43$)	41–60% ($n=50$)	61–100% ($n=16$)	Total *n*% ($n=175$)
LB score (CFU/ml)						
$0–10^3$	0	0	0	4	3	7 (4)
$10^3–10^4$	1	9	13	25	13	60 (34)
$10^4–10^5$	2	28	26	20	0	74 (42)
$>10^5$	3	29	4	1	0	34 (19)
Diet frequency/day						
Max. 3 meals	0	12	22	21	8	63 (36)
4–5 meals	1	20	16	26	8	70 (40)
6–7 meals	2	26	4	3	0	33 (19)
>7 meals	3	8	1	0	0	9 (5)
Amount of plaque						
PI <0.4	0	0	0	1	1	2 (1)
PI =0.4–1.0	1	4	10	29	10	53 (30)
PI =1.1–2.0	2	52	30	19	5	106 (61)
PI >2.0	3	10	3	1	0	14 (8)
MS score (CFU/ml)						
$0–10^3$	0	0	1	3	2	6 (3)
$10^3–10^4$	1	3	5	16	13	37 (21)
$10^5–10^6$	2	24	21	31	1	77 (44)
$>10^6$	3	39	16	0	0	55 (31)
Secretion rate (ml/min)						
≥1.1	0	54	36	44	15	149 (85)
0.9–1.1	1	8	6	6	1	21 (12)
0.5–0.9	2	4	1	0	0	5 (2)
<0.5	3	0	0	0	0	0
Buffer capacity (pH)						
>5.5 (Blue)	0	2	17	32	12	83 (47)
5.5–4.5 (Green)	1	26	17	17	4	64 (37)
<4.5 (Yellow)	2	18	9	1	0	28 (16)
Fluoride (F) program						
Constant additional F	0	0	0	0	0	0
Infrequent additional F	1	0	0	0	0	0
Toothpaste with F only	2	38	39	50	16	143 (82)
No F programme	3	28	4	0	0	32 (18)

A chair-side test (CRT Bacteria®, Ivoclar-Vivadent, Schaan, Liechtenstein) was used to evaluate both mutans streptococcus (MS) and lactobacillus (LB) counts. The MS and LB were scored in four classes according to the model chart provided (0, 1, 2, and 3; see Table I). According to the Cariogram, the LB score is used for "diet content" [15,16]. The buffer capacity of the stimulated saliva was determined using CRT Buffer® (Buffer Strip; Ivoclar-Vivadent). Three colours were obtained: blue (pH >5.5), green (pH < 5.5 to 4.5), and yellow (pH <4.5), according to Kitasako et al. [17] (see Table I).

Statistical analysis

All the data were analysed using the SPSS statistical package (version 11.0, SPSS Inc., Chicago, Ill., USA). Descriptive statistics, including the means and standard deviations of all caries-related factors, were calculated for the 175 individuals and for the four caries risk groups. Analysis of variance (ANOVA), followed by Scheffé's test of multiple comparisons, was used to compare the mean numbers of DiS, Di+mS, FS, and Di+mMFS between the four risk groups. *P*-values below 0.05 were considered statistically significant.

Results

In all, 120 radiographs from 35 individuals were re-evaluated after 1 month by the same examiner for intra-examiner reliability (Cohen's kappa value = 0.77).

The number of teeth, DiS, Di+mS, MS, FS, DmMFS, and Di+mMFS are presented in Table II. Mean differences in gender were not statistically significant apart from FS ($p<0.05$; data not shown); females showed more FS than males. The mean (SD) numbers of initial caries lesions were 3.5 (3.0), diagnosed clinically, and 5.3 (3.0), diagnosed

Table II. Mean (SD) for different caries variables both clinically and radiographically in 175 adults.

Variables	Mean (SD)	Range
No. of teeth	26.0 (2.2)	19–28
Caries indices		
DmMFS	50.2 (19.9)	12–114
Di+mMFS	53.8 (19.8)	14–114
Total decayed surfaces (Di+mS)	19.3 (13.4)	2–77
Missing surfaces (MS)	11.8 (10.8)	0–45
Filled surfaces (FS)	22.6 (16.0)	0–76
Caries lesions (clinically)		
Initial lesions	3.5 (3.0)	0–13
Dentin lesions	6.0 (10.0)	0–59
Recurrent lesions	2.5 (2.9)	0–20
Total lesions	12.0 (11.4)	0–63
Caries lesions (radiographically)		
Initial lesions	5.3 (3.0)	0–15
Dentin lesions	1.1 (1.6)	0–9
Recurrent lesions	0.9 (1.2)	0–5
Total lesions	7.3 (3.9)	0–18

radiographically. The mean numbers of recurrent caries lesions, clinically and radiographically, were 2.5 (2.9) and 0.9 (1.2), respectively.

The means of "percentage chance of avoiding caries" for the four risk groups were 11 (5.3)%, 29 (5.2)%, 49 (5.5)%, and 66 (4.6)%, respectively. The mean (SD) for the total of 175 individuals was 31 (19.7)%, with a range of 3–73% (data not shown).

All caries-related factors, assessed and weighted by the Cariogram program, i.e. salivary secretion rate, buffer capacity, amount of plaque, cariogenic diet (expressed as LB count), intake frequency, MS count, and fluoride program, are given in Table I. The LB count $\geq 10^4$ CFU/ml saliva (Cariogram score 2+3) was 42+19 = 61% of the 175 individuals. The corresponding value for the MS count $\geq 10^5$ CFU/ml saliva was 44+31 = 75%. For amount of plaque, 61% ($n = 106$) had a PI between 1.1 and 2 and 8% ($n = 14$) had a PI more than 2. In the questionnaire data, some individuals, i.e. 19% ($n = 33$), never or very rarely brushed their teeth with fluoride toothpaste. Of the remaining, 36% ($n = 63$) answered that they infrequently (i.e. not every day) used toothpaste with fluoride, while 45% ($n = 79$) used it frequently (i.e. every day). No one used fluoride mouth rinse solutions or tablets.

Figure 1 shows four box plots of total initial and manifest caries lesions (Di+mS), total initial caries lesions (DiS), number of filled tooth surfaces (FS), and finally Di+mMFS for the four risk groups. In Table III, the results of DiS and Di+mS revealed that the corresponding mean values in the high-risk group were higher than in the other three groups; DiS ($p < 0.05$) and Di+mS ($p < 0.01$). The corresponding value of FS in the high-risk group was lower than in the other risk groups ($p < 0.05$) (Table III).

The mean values for age, DiS, Di+mS, FS, and Di+mMFS in each risk group are presented in Table III. The mean value for Di+mMFS was similar in the four risk groups (NS).

Discussion

The Cariogram is regarded as a useful tool for assessing and predicting caries risk and it has been investigated and validated for use in the case of both children and elderly individuals [7,8]. Nevertheless, Cariogram has been used in several cross-sectional studies [18–20]. The present study also has a cross-sectional design; hence, we are not evaluating the capability of the Cariogram to predict caries. The Cariogram was used to estimate the risk of developing caries in the future for this particular group, and to identify the caries-related factors contributing to that risk. We believe that all dentists should use the Cariogram in their daily clinical practice. Indeed, that would help them to allocate their patients to the right caries risk category, and to identify the caries-related factors that could be modified accordingly. As a result, the treatment plan for caries management could be formulated and optimized to be more preventive and conservative not just by treating the patients with more fillings and exposing them to further risk [21].

The main finding in the present investigation was that the majority of the patients might be at high risk of having caries in the future; the high and medium risk groups (66+43) of the 175 individuals (62%) had a <40% "chance of avoiding caries" according to the Cariogram. If the entire population is taken into consideration, the mean Cariogram value is only 31%, which is a very low value, i.e. a high caries risk in the future. Of the various caries-related factors included in the Cariogram model, four obtained high Cariogram scores (i.e. 2–3) in the majority of patients. These factors are lactobacilli (LB), mutans streptococci (MS), plaque index (PI), and use of fluoride. These factors could explain both the high caries status of the individuals and the probability of having a high risk of developing caries lesions in the future.

When we divided the patients into four risk groups, there were statistically significant differences between various clinical caries variables such as Di+mS and DiS and the risk groups. The high-risk group differed significantly from the other (Table III). Neither of these two indices is specifically included in the Cariogram model, but they are generally involved in the caries experience factor, i.e. DMFT or DMFS. As Hänsel-Petersson et al. [8] have stated: "Past caries experience could be looked upon as a risk marker, as it points towards an increased probability of more caries, but is definitely not a causal factor. In the Cariogram calculations, this factor is included, but given much less weight than the important modifiable risk factors, such as bacteria, diet and fluoride, among others, which are

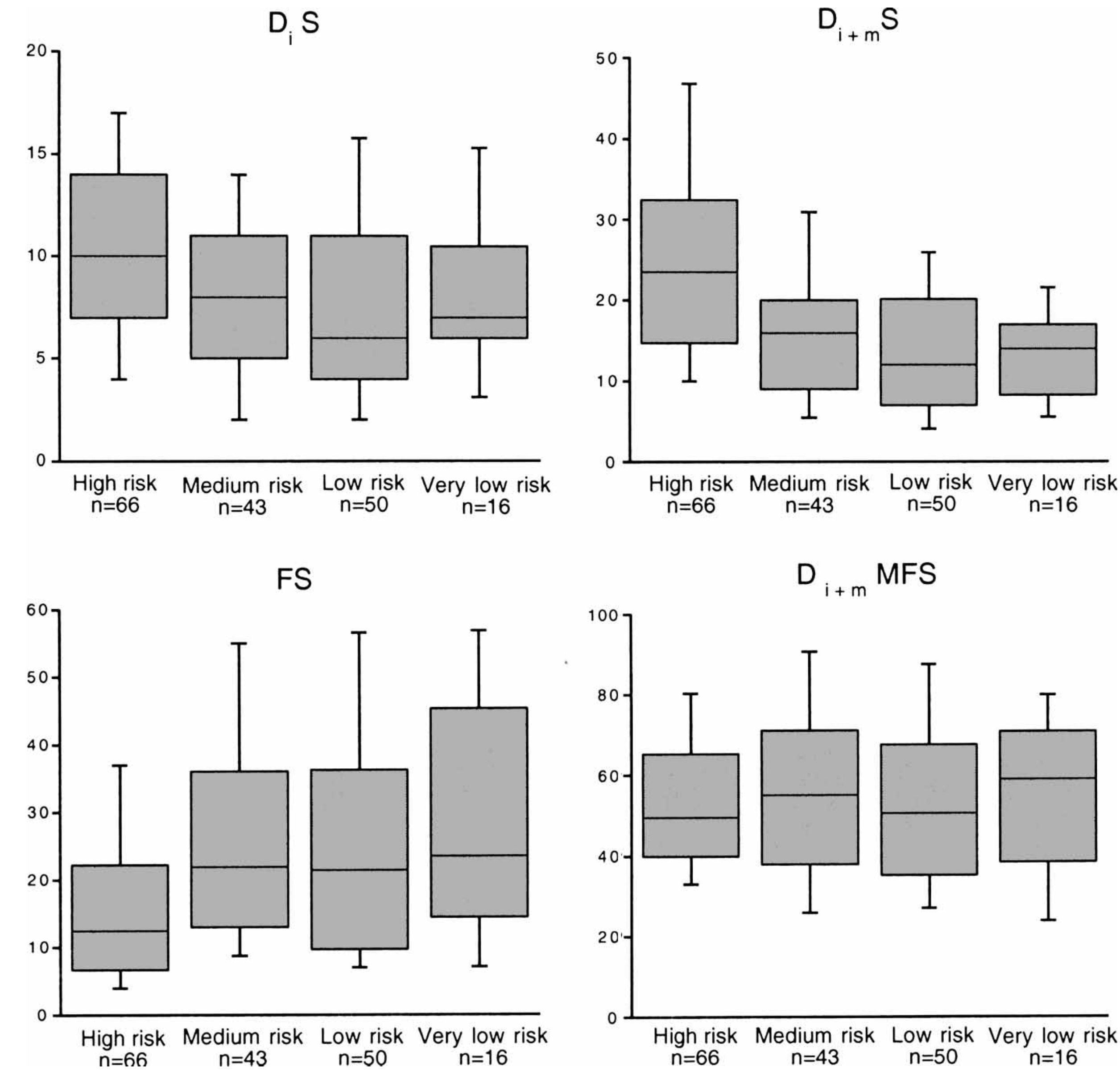

Figure 1. Box plots of DiS (total initial caries lesions), Di+mS (total decayed tooth surfaces), FS (filled teeth surfaces), and Di+mMFS (decayed, missing, and filled tooth surfaces) variables for all risk groups according to the percentage chance of avoiding caries. The line within the box indicates the median value; the lower and upper bounds indicate the 25th and 75th percentiles, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively.

part of the causal chain." The reason for this is that the Cariogram model was originally developed to predict future caries lesions. In Table III, the mean Di+mMFS values are almost equal in the four risk groups, although they might differ in terms of caries risk. We therefore analyzed various components of the DFS index, such as DiS, Di+mS, and FS, independently between the risk groups. The high-risk group differed significantly from the other three groups (Table III). From a clinical point of view, this

Table III. Mean (SD) values of percentage chance of avoiding caries, DiS, Di+mS, FS, and Di+mMFS in each risk group according to the Cariogram. For the mean values of DiS, Di+mS, FS, and Di+mMFS, see Table II.

Risk group	*n*	Mean (SD) % chance of avoiding caries	Age (years)	DiS		Di+mS		FS		Di+mMFS
High	66	11.0 (5.3)	26.5 (7.9)	10.5 (4.9)		26.0 (15.5)		16.5 (12.3)		53.0 (17.9)
Medium	43	29.0 (5.2)	31.4 (11.1)	8.1 (4.3)	*	17.3 (12.1)	**	26.8 (17.2)	*	55.6 (22.0)
Low	50	49.0 (5.5)	31.1 (9.6)	7.6 (4.8)		13.9 (8.5)		25.1 (16.7)		52.8 (20.9)
Very low	16	66.0 (4.6)	31.4 (10.1)	8.0 (3.8)		13.7 (6.4)		28.8 (17.7)		55.1 (19.1)
Total	175	31 (19.7)	29.5 (9.7)							

*$p<0.05$; **$p<0.01$. ANOVA with Scheffé for multiple comparisons.

could be interpreted in two ways. First, since the other caries-related factors have been weighted, the presence of a high number of DiS or Di+mS might indicate the caries status of the individual on the day of examination. For example, if an individual has several DFS, this does not mean that he or she has high caries activity unless the other caries-related factors are evaluated. This might be of help for instance in determining how frequently this patient should be followed up. Second, if a patient with high DiS and Di+mS values is treated without consideration and weighting of the other caries-related factors, "modifiable risk factors", most dentists will probably start to "drill and fill" and thereby expose the patient to a greater caries risk.

One finding that might be slightly confusing is that the high-risk group had the smallest number of FS, which differed significantly from the other three risk groups. The reason could be that these individuals might have a high number of recurrent caries, consequently counted as decayed rather than as FS. In addition, it should be pointed out that many patients in this group did not use any fluoride program (Table I). This reflects less motivation for and awareness of dental care than the other risk groups, rendering them more likely to run a high risk of caries.

Adding approximal caries lesions, diagnosed by bitewing radiographs, to the DS variable might be beneficial for caries-status evaluation [22]. Today, this type of caries is quite common in teenagers and young adults [23,24]. In the present study, 38% of the total caries lesions were diagnosed via bitewing radiographs. In patients with several dental restorations in particular, as in our study, the detection of approximal caries by bitewing radiograph is important. According to Powell [5], approximal tooth surfaces become better predictors, therefore indicating the importance of the bitewing radiographs. Furthermore, X-rays might be a useful tool for detecting recurrent caries. Nevertheless, the location of recurrent caries, the angle of the radiograph, and the type of restoration might obstruct their diagnosis [25,26]. Clear guidelines should therefore be drawn up with regard to the radiographic and clinical appearance of recurrent caries.

In conclusion, the Cariogram model can identify the caries-related factors that could be the reasons for the estimated future caries risk, and therefore help the dentist or dental hygienist to plan appropriate preventive and treatment measures in daily clinical practice. In addition, there is a direct association between the categorized outcomes of the Cariograms and DiS and Di+mS indices.

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