

Caries risk assessment in children: experimental study on the effectiveness of the C.A.M.B.R.A. system



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Abstract

Background The caries risk assessment (CRA) is the set of procedures that aim to determine a personalised treatment of the caries pathology in the patient. CRA establishes the probability to develop carious lesions over a certain time period or the likelihood that there will be a change in size or activity of lesions already present [Kriegler et al., 2021]. This "assessment" occurs in two phases: the first phase is to determine specific disease indicators, risk factors, and protective factors each patient has such as the presence of bacterial biofilm, the quantity and quality of saliva, the quality and quantity of the patient's diet, the presence or absence of a correct lifestyle from a hygienic point of view; the use of fluoride and calcium phosphate substances; In the second phase a risk level is assigned to the patient (low, moderate, high, or extreme) in order to allow an individualised treatment plan, which combines restorative treatments with a preventive chemical therapy [Featherstone and Chaffee, 2018; Khallaf et al., 2021]. The aim of this preliminary study is to analyse the correlation of caries with the risk factors related in young patients from 6 to 12 years old, associated to moderate and severe risk levels of caries.

Methods This was a cross-sectional and descriptive study that included 64 children and adolescents aged from 6 to 12 years, considering the possible and possible samples not acceptable to the study, due to the exclusion criteria. Inclusion criteria were as follows: all children visiting the pediatric dental clinic who co-operated during the oral examination who have from "moderate" to "high" risk of caries according with CAMBRA [Featherstone et al., 2007].

Results The sample consisted of 64 subjects, of which only one with a C.R.A. score less than 11 (score 1 for the compliance factor, workable soil index, and score 3 for the fluorine factor to indicate no fluoroprophyllactic measure) and was considered "low risk". This patient was excluded from the subsequent analysis, which compared subjects with a C.R.A. score of 11-15 ("high risk", n = 29) with those with a score of 16-27 ("extreme risk", n = 34).

Conclusions The results showed that patients at extreme risk of tooth decay compared to high-risk patients, not only had all the highest rating rates, but also had more difficulty changing their habits. We can therefore conclude that both the risk of caries is directly proportional to a worsening of the clinical conditions and the delay of the intervention by the clinician is itself a risk factor.

KEYWORDS Caries, Risk factor, DMFT, High/ Extreme Risks.

Introduction

The WHO Global Oral Health Status Report (2022) estimated that oral diseases affect close to 3.5 billion people worldwide, with 3 out of 4 people affected living in middle-income countries. Globally, an estimated 2 billion people suffer from untreated caries of permanent teeth and 514 million children suffer from untreated caries of primary teeth [WHO,2022]. The

prevalence of the main oral diseases continues to increase globally with growing urbanisation and changes in living conditions. This is mainly due to the availability and affordability of high-sugar foods and poor access to oral health care services in the community, despite adequate fluoride exposure (in the water supply and oral hygiene products such as toothpaste). Marketing of food and beverages high in sugar, as well as tobacco and alcohol, have led to a growing consumption of products that contribute to oral health conditions and other NCDs [WHO, 2022]. It has become well-established that dental caries has a multifactorial etiology including the interaction among numerous species of bacteria, dietary habits, and host response [Featherstone, 2021], complicated by social determinants of health and the presence of malocclusions and/or the presence of orthodontic devices.[Butera et al., 2022; Caruso et al., 2023; Nota et al., 2022; Dianiskova et al., 2023]. Dental caries occurs due to the demineralisation of enamel and dentine by the organic acids formed from bacteria present in dental plaques through anaerobic metabolism of dietary sugars [Wei et al., 2022]. While traditional dental treatment emphasises restorative (conservative or prosthetic) treatment [Khallaf et al., 2021] of disease manifestation (caries or caries), modern Minimally Invasive Dentistry (MID) focuses on the cause of the disease, evaluating the risk assessment of individual patients to determine disease indicators, risk factors, and protective factors [Severino et al., 2021]: among the risk factors, in fact, there are certainly enamel defects and dental erosion, frequency of sugar and carbohydrate intake, quality and quantity of saliva, socioeconomic status and oral family health, and special conditions [Wei et al., 2022]. Protective factors include sealing, remineralisation (fluoride substituted as biomimetic hydroxyapatite and calcium phosphate), good oral hygiene and periodic check-ups. Dental caries is a dynamic, preventable, reversible disease [Nota et al.,2020], and the primary prevention is necessary to create healthy habits in order to reduce the risk of caries and to avoid its further development [Yeo et al., 2022]. The caries risk assessment is the set of procedures that aim to determine a personalised treatment of the caries pathology in the patient. CRA establishes the probability to develop carious lesions over a certain time period or the likelihood that there will be a change in size or activity of lesions already present [Kriegler and Blue, 2021]. Among the different methods in the literature that assess caries risk, one of the most widespread is

the CAMBRA method [Ferrazzano et al., 2023]. The CAMBRA (caries management by risk assessment) CRA tool was developed over decades by personnel at the UCSF (University of California San Francisco), is based upon research on key factors that contribute to caries progression or reversal. The tool was launched in the clinics at UCSF in 2003 and has been updated since then based upon clinical outcomes [Featherstone, 2021]

This "assessment" occurs in two phases: the first is to determine specific disease indicators, risk factors, and protective factors each patient has:

- the presence of bacterial biofilm, in particular the species of *Streptococcus mutans*, therefore the acidogenic plaque, capable of fermenting and inducing cariogenic processes;
- the quantity and quality of saliva, therefore knowing the salivary properties of the individual patient, understanding if the buffering power of saliva is functioning correctly;
- the quality and quantity of the patient's diet, the introduction of fermentable carbohydrates, the frequency of food intake;
- the presence or absence of a correct lifestyle from a hygienic point of view;
- the use of fluorine and calcium phosphate substances.

In the second phase a risk level is assigned to the patient (low, moderate, high, or extreme) in order to allow an individualised treatment plan, which combines restorative treatments with a preventive chemical therapy [Featherstone and Chaffee, 2018; Khallaf et al., 2021].

There is a lot of controversy about which of the multiple factors involved in the disease can really impact on it, therefore is the necessity of the improving the efficiency and effectiveness of preventive procedures and programs. Better and more cost-effective treatment can be provided by updating the information related to caries and the specific risk factors among [Ferrazzano et al., 2022]. One of the main limitations of this method concerns its lack of specificity and reproducibility, since being operator-dependent it has been seen that some aspects evaluated find greater attention depending on the clinician who analyses them [Featherstone et al., 2007]. Another limitation concerned the possibility of having a complete caries risk assessment system, for this reason in the subsequent work the data generally collected in the CAMBRA method will be integrated with aspects from other evaluation systems such as the Cariogram such as the buffering capacity of saliva or considerations closely related to the operator who performs the test [Emiliani, 2023]. Our goal is in fact to be able to use as a survey tool an evaluation method on the basis of that Cambra, from which derive the reference risk classes of patients, but integrated with different values present in Cariogram (e.g. saliva buffering capacity) [Emiliani, 2023]. The aim of this preliminary study is to analyse the correlation of caries with different risk factors in young patients aged 6 to 12 years, associating each with a low, moderate or severe level of caries risk.

Materials and Methods

This was a cross-sectional and descriptive study carried out during the period January-March 2023, in the University Pediatric Dental Clinic of Università degli Studi dell'Aquila (Italy). A minimum sample size of 52 subjects was determined via the G*Power Software Program (power = 0.75, alfa = 0.05, beta = 0.25, G * Power Ver : 3.1.9.2.). This study included 64 children and adolescents aged from 6 to 12 years, considering the possible and possible samples not acceptable to the study, due to the exclusion criteria. Inclusion criteria were as follows: all children visiting the pediatric dental clinic who co-operated during the

oral examination who have from "moderate" to "high" risk of caries according with CAMBRA [Featherstone et al., 2007]. Exclusion criteria were as follows: children with disabilities that may affect oral hygiene practices were excluded and children who did not cooperate during the dental clinical examination process. Prior approval from the Institutional Ethical Committee n. 54954 del 25/09/2018 was obtained before launching the study. A signed consent from the parents of the children (guardians) was obtained before approval to conduct the interviews and dental examination.

Data collection was performed by a single examiner. The individual risk of each patient in this study was determined according CAMBRA using a modified template [Featherstone et al., 2007] for categorised as "low risk" (no carious lesions, no plaque, optimal fluoride use, and regular dental care); "moderate risk" (carious lesion in previous 12 months, visible plaque, suboptimal fluoride, and irregular dental care); and "high risk" (one or more carious lesions, visible plaque, suboptimal fluoride, no dental care, high bacterial challenge, and inadequate saliva flow) .

Statistical analysis

The sample, stratified in two groups (high risk vs extreme risk) on the basis of the C.R.A., was subject to descriptive analysis. In fact, there were no subjects with low risk in statistically significant terms. The statistical significance of the comparisons between the categorical variables was assessed through the exact Fisher test or χ^2 test, as appropriate. In the presence of statistical significance, variables were introduced in a multivariate logistics regression model in order to identify factors independently associated with extreme risk, with associations reported as odds ratios (ORs), corrected for other factors in the model, and 95% confidence intervals (95% CI). The backward stepwise selection using the Akaike information criterion (AIC) was used to identify the best multivariate model.

The analysis was carried out using the software STATA/BE 17.0 and the values of $p < 0.05$ were considered statistically significant.

Results

The sample consisted of 64 subjects, of which only one with a C.R.A. score less than 11 (score 1 for the compliance factor, workable soil index, and score 3 for the fluorine factor to indicate no fluoroprophyllactic measure) and was considered "low risk". This patient was excluded from the subsequent analysis, which compared subjects with a C.R.A. score of 11-15 ("high risk", $n = 29$) with those with a score of 16-27 ("extreme risk", $n = 34$). From the descriptive statistical analysis, significant differences emerged between the two groups in question for compliance ($p = 0.017$), plaque index ($p = 0.004$), frequency of intake of foods rich in sugar or acids ($p = 0.048$), amount of saliva stimulated ($p = 0.001$) and buffer capacity ($p = 0.026$). In particular, it emerged that all subjects at high risk showed willingness to accept the proposed changes against 79.41% of subjects at extreme risk (100% vs 79.41%, $p = 0.013$), among which instead there was a share equal to 17.65% with low accommodation capacity (17.65% vs 0.00%, $p = 0.027$). The plaque index between 10% and 25% was found more frequently in the high risk group (37.93% vs 11.76%, $p = 0.019$), while among extreme risk subjects there was more frequent plaque index greater than 50% (67.65% vs 27.59%, $p = 0.002$), as well as a higher frequency of intake of sugary or acidic foods. Xerostomia was found exclusively in extreme risk subjects

(26.47% vs 0.00%, p=0.003), while a stimulated saliva amount > 5.5 ml/5 min was more frequent among high-risk subjects (51.72% vs 14.71%, p=0.003). Finally, buffer capacity between 10 and 12 points was more frequent in the high-risk group than in the extreme group (62.07% vs 29.41%, p=0.012), where buffer capacity was more frequently between 6 and 9 points (61.76% vs 34.48%, p=0.044) (Tab. 1). The multivariate logistic regression model showed that hyposcialia and a buffer capacity between 6 and 9 points are independently associated with extreme risk (OR 16.29, 95% CI 2.38 – 51.49, p=0.004 and OR

12.91, 95% CI 2.25 – 73.92, p=0.004, respectively). Xerostomia turns out to be a perfect predictor of extreme risk (Tab. 2).

Discussion

Based on the information collected during the observational phase and data on exposure to risk or protective factors for the development of caries, the clinician can establish the CRA of the patient. As already mentioned, through physical examination and anamnestic analysis the clinician is able to classify a subject

	Total N=63	Risk level		p-value*
		High n (%) 29 (46.03)	Extreme n (%) 34 (53.97)	
DMFT, n (%)				0.999
Normal DMF-T values compared to age group: a clinically evident lesion or secondary caries within the last 3 years.	1 (1.59)	0 (0.00)	1 (2.94)	
Worse DMF-T values than the age group: presence of two or more lesions primary or secondary developed within 12 months of the last cariological evaluation or more than two lesions in the last 3 years.	62 (98.41)	29 (100.00)	33 (97.06)	0.495
Anamnesis, n (%)				
None - Deleted	61 (96.83)	29 (100.00)	32 (94.12)	
Momentary – In reduction -Controlled	2 (3.17)	0 (0.00)	2 (5.88)	
Compliance, n (%)				0.017
Fertile soil: maximum accommodation capacity; full willingness to accept proposed changes.	1 (1.59)	0 (0.00)	1 (2.94)	
Workable soil: presence of conditions to be accepted; willingness to accept the proposed changes.	56 (88.89)	29 (100.00)	27 (79.41)	0.013
Rigid soil: poor accommodation capacity; apparent unwillingness to accept the proposed changes.	6 (9.52)	0 (0.00)	6 (17.65)	0.027
Plaque index, n (%)				0.004
10% - 25%	15 (23.81)	11 (37.93)	4 (11.76)	0.019
26% - 50%	17 (26.98)	10 (34.48)	7 (20.59)	
>50%	31 (49.21)	8 (27.59)	23 (67.65)	0.002
Nutrition quality, n (%)				0.455
1	3 (4.76)	2 (6.90)	1 (2.94)	
2	20 (31.75)	11 (37.93)	9 (26.47)	
3	40 (63.49)	16 (55.17)	24 (70.59)	
Feeding (frequency of intake), n (%)				0.048
≥ 1 sugars e/o ≥2 acids	35 (55.56)	20 (68.97)	15 (44.12)	
≥ 3 sugars e/o ≥ 4 acids	28 (44.44)	9 (31.03)	19 (55.88)	
Amount of saliva stimulated, n (%)				0.001
>5.5 ml/5 min	20 (31.75)	15 (51.72)	5 (14.71)	0.003
4.5-5.5 ml/5 min	11 (17.46)	6 (20.69)	5 (14.71)	
2.5-4.5 ml/5 min (iposcialia)	23 (36.51)	8 (27.59)	15 (44.12)	
< 2.5 ml/5 min (xerostomia)	9 (14.29)	0 (0.00)	9 (26.47)	0.003
pH saliva, n (%)				0.060
>6.8	55 (87.30)	28 (96.55)	27 (79.41)	
5.8-6.8	8 (12.70)	1 (3.45)	7 (20.59)	
Buffer capacity, n (%)				0.026
10-12 punti	28 (44.44)	18 (62.07)	10 (29.41)	0.012
6-9 punti	31 (49.21)	10 (34.48)	21 (61.76)	0.044
0-5 punti	4 (6.35)	1 (3.45)	3 (8.82)	
Fluoro, n (%)				0.099
Regular use of fluoride toothpastes and additional measures	1 (1.59)	0 (0.00)	1 (2.94)	
Use of fluoride toothpaste and sporadic additional measures	4 (6.35)	4 (13.79)	0 (0.00)	
Use of fluoride toothpaste only	23 (36.51)	9 (31.03)	14 (41.18)	
No fluoroprophylactic measures	35 (55.56)	16 (55.17)	19 (55.88)	
*test esatto di Fisher o χ2 test				

TABLE 1 C.R.A. factors (absolute frequencies and percentages, stratified by risk group)

	OR#	IC 95%	p-value
Feeding (frequency of intake)			
≥ 1 sugars e/o ≥ 2 acids	1		
≥ 3 sugars e/o ≥ 4 acids	3.85	0.86 – 17.25	0.078
Amount of saliva stimulated			
>5.5 ml/5 min	1		
4.5-5.5 ml/5 min	3.15	0.47 – 21.01	0.235
2.5-4.5 ml/5 min (iposcialia)	16.29	2.38 – 51.49	0.004
< 2.5 ml/5 min (xerostomia)	predicts success perfectly		
Buffer capacity			
10-12 punti	1		
6-9 punti	12.91	2.25 – 73.92	0.004
0-5 punti	11.66	0.35 – 88.43	0.170
a: Reference category, # corrected for other factors in the model, AIC=62			

TABLE 2 Multivariate logistic model of factors associated with extreme risk

at high, medium or low risk of developing carious pathology and consequently apply the corresponding treatment. In the following work will be considered patients at high and extreme risk of caries, on the other hand, the low-risk patient was excluded as only one was found and it is not possible to evaluate it statistically.

In summary, the C.A.M.B.R.A. method consists in implementing safeguards in order to modify risk factors in a “constructive” way. This constructive change therefore concerns [Ferrazzano et al., 2012]:

1. Saliva
2. Diet
3. Exposure to fluorides
4. The accumulation of bacterial plaque
5. Factors that favor the carious process (pathologies, drugs, etc.)

The salivary bacterial test will represent the photograph of the patient’s caries risk state before any restorative or prosthetic intervention. The patient at high risk of caries will undergo an intervention procedure and subsequently a new salivary test will be conducted, which will probably have to show a reduction in the concentration of cariogenic bacteria and therefore a reduction in the patient’s C.R.A., thus being able to frame it in a lower risk level and apply all maintenance measures for the level obtained. The results show a worsening of the evaluated indices (plaque index, consumption of sugars or acids) in subjects at extreme risk of caries compared to moderate subjects, with greater difficulty in accepting changes and changing their habits in subjects at extreme risk compared to moderate subjects. This indicates the importance of early intervention in the diagnosis and evaluation of caries risk to ensure that the factors that influence the disease become reversible. As far as nutrition is concerned, this will be considered with respect to the intake of sugary or acidic foods greater than 5 times a day, therefore with respect to both frequency and quality. The patient at extreme risk of caries, moreover, also shows an important reduction in the functionality of the salivary glands, and therefore of the salivary flow, with a reduction in the amount of saliva stimulated, not present instead in the moderate-risk patient. This result therefore highlights the higher level of C.R.A. and requires more specific and intensive therapy than the moderate-risk patient.

Conclusions

The caries risk assessment through the C.A.M.B.R.A. method turns out to be one of the most reliable methods but despite this there are still limits related to the operator and to the fact that to classify the patient in a certain group, at high or extreme risk of caries, the patient should be followed periodically by repeating the analysis. From the following work it emerged, moreover, how patients at extreme risk of caries compared to patients at moderate risk, not only had all the highest evaluation indices but also had more difficulty in changing their habits. We can therefore conclude that both the risk of caries is directly proportional to a worsening of the clinical conditions and the delay of the intervention by the clinician is itself a risk factor.

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