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Caries risk assessment methods: An overview

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Abstract
Dental caries preventive approaches must be integrated based on knowledge and understanding of the predicted risk. Caries risk assessment is a concept that is firmly grounded on the well-known fact that dental caries is a preventable disease**.** It denotes the process of establishing the probability for an individual patient to develop new caries lesions over the near future. In caries risk assessment methods, patients who are at risk are identified, factors that are directly or indirectly responsible for the disease are eliminated/reduced, and measures are taken to prevent future disease. This review article discusses the various methods used in caries risk assessment. The articles were searched in Pubmed and Google scholar database, a total of 18 articles were reviewed from 2006 to 2020. Caries risk assessment is the critical component of dental caries management and should be considered a standard of care and included as part of the dental examination. Although Caries Risk Assessment utilization rates are low among general dentists, with continued development of supporting evidence and guidelines Caries Risk Assessment will increasingly become the accepted standard of care.

Keywords: Dental caries, caries risk assessment, cariogram, CAMBRA

Introduction
Dental caries, the most typical oral disease, affecting both children and adults worldwide. High prevalence of primary and secondary caries in at risk populations result in significant lifetime costs. Validated assessment strategies, such as the caries risk assessment methods, allow dental providers to implement a systematic and evidence-based approach to astutely assess and record changes in the caries risk status of patients in an attempt to stop disease [1].

Caries preventive approaches must be integrated based on knowledge and understanding of the predicted risk. The risk model and the prediction model, are the two different approaches described for caries risk assessment. The risk model is employed to work out the causative caries factors called risk factors but it cannot predict the caries outcome. The prediction model estimates the danger of caries progression within the future. Risk models counting multiple variables end in better predictions because the disease process is multifactorial [2].

Incorporation of caries risk assessment as a motivating tool for patients encouraging them to undertake measures that will move them from a high or moderate risk category to a low risk category. Risk assessment can thus also contribute to a more efficient allocation of your time and resources for oral health programs by eliminating many unnecessary interventions, e.g. Professional topical fluoride applications in a low caries risk child. Besides this, Caries Risk Assessment can potentially promote caries prevention at the primary level itself i.e. before the initiation of the disease process. This could enable even high caries risk children to reach adulthood caries free- a goal every dentist strives to achieve for their patients [3]. This article is an attempt to highlight the various methods used in caries risk assessment.

Materials and Methods
The articles were searched in Pubmed and Google scholar database, a total of 18 articles were reviewed from 2006 to 2020. A number of Caries Risk Assessment methods have been proposed for use in clinical practice as follows [3].
AAPD's caries risk assessment Form, Cariogram Model, Caries assessment and risk evaluation (CARE) test, Caries management by risk assessment (CAMRA), Traffic light matrix (TLM), Cariometer App, Lactic acid impression.

1. AAPD's Caries Risk Assessment Form

American Academy of Pediatric Dentistry (AAPD) recognizes that caries risk assessment and management protocols, also known as care pathways, can aid clinicians with decisions regarding treatment based upon child's age, caries risk and patient compliance and are essential elements of contemporary clinical care for infants, children and adolescents. The document was developed by the Council on Clinical Affairs and adopted in 2002 and last revised in 2019 [4].

Caries Risk Assessment forms were formulated that can be used by dentists to evaluate caries risk status for 0–5 year old and ≥6 year old children. Risk assessment categorization of low, moderate, or high is based on the preponderance of factors for the individual. Care pathways are documents for caries management designed to aid in clinical decision-making; provide criteria regarding diagnosis and treatment and lead to recommended courses of action. Care pathways for caries management in children aged 0-2 and 3-5 years old were first introduced in 2011. Caries risk assessment for children further refine the decisions concerning individualized treatment and treatment thresholds based on a specific patient's age, risk levels, and compliance with preventive strategies. Such clinical pathways yield greater probability of success, fewer complications, and more efficient use of resources than less standardized treatment [5].

2. Cariogram Model

Cariogram is a graphical picture illustrating in an interactive way the individual's or patient's risk for developing new caries in the future, simultaneously expressing to what extent different etiological factors of caries affecting the caries risk for that particular patient. The cariogram, by explaining the caries risk graphically, depicts the 'chance' for promotion of a new carious lesion in the near future and might illustrate to what extent various factors might affect this chance. The Cariogram states a particular number of cavities that will or will not occur in the future. It rather elucidates a possible over-all risk picture, based on the interpretation of gathered information [6].

The Swedish version of the Cariogram was first launched officially in November 1997 by Proffessor Douglas Bratthall at the Faculty of Odontology at Malmo University College in Sweden after extensive trials. It has been translated into several languages to be used in different countries. Cariogram as an interactive PC-program developed for educational, preventive and clinical purposes. The main aim of the Cariogram is to demonstrate the caries risk graphically, expressed as the "Chance to avoid new caries" (i.e. to avoid getting new cavities') in the near future. It also demonstrates to what extent various factors affect this 'Chance'. A further propose of this program is to encourage preventive measures to be introduced before new cavities could develop [6].

3. Caries Assessment and Risk Evaluation (CARE) test

Researchers at the Division of Diagnostic Sciences of the University of Southern California School of Dentistry developed a novel salivary test for genetic Caries risk assessment called the CARE test [7] based on the high correlations between caries history and quantities of specific oligosaccharides in whole saliva. Certain salivary oligosaccharides are known to facilitate bacterial attachment, while other salivary sugar chains promote agglutination and removal of free bacteria. In the case of the former, there is a positive correlation with caries experience, while for the latter, a negative correlation is seen. Since the pattern of these salivary oligosaccharides is 100% genetically determined, identifying individual salivary oligosaccharide concentrations can help determine the genetic risk of the child to develop caries. The CARE test is probably the only Caries Risk Assessment method that can potentially promote caries prevention at the primary level itself (before any carious lesions have appeared), by identifying high caries risk children early and instituting a preventive regimen in them. The widespread incorporation of the CARE test in clinical practice and its use in conjunction with other more traditional risk assessment methods is probably the future of dental Caries Risk Assessment.

4. C Aries management by risk assessment (CAMBRA)

CAMBRA philosophy of care is the assessment of each patient for his or her unique disease indicators, risk factors and protective factors to determine current and future dental caries disease [8]. The caries imbalance model was created to represent the multifactorial nature of dental caries disease and to emphasize the balance between pathological and protective factors in the caries process. Progression or reversal of caries disease is determined by the imbalance between disease indicators and risk factors on one side and the competing protective factors on the other side.

In response to the lack of a universally accepted carious lesion detection system, a group of cariologists and epidemiologists generated the International Caries Detection Assessment System (ICDAS) in 2002 in Scotland [9]. This visual system was developed as a detection system for occlusal carious lesions, with a two-digit coding system: The first digit (0-9) identifies the tooth status, and the second digit (0-6) describes the severity of the caries disease. Once the clinician has identified the patient's caries risk, a therapeutic and/or preventive plan should be implemented. For example, if an adult is classified as moderate risk to caries, the guideline proposes recall visits every 4–6 months. If the same patient were classified as low-risk, the recall intervals suggested would then be for every 6–12 months.

5. Traffic Light Matrix (TLM)

Traffic Light Matrix is a commonly used CRA tool in Australia. It is based on 19 criteria in 5 different categories including saliva (6 criteria), plaque (3 criteria), diet (2 criteria), fluoride exposure (3 criteria), and modifying factors (5 criteria) [10].

- Saliva:
a. Resting: hydration, viscosity, pH
b. Stimulated: quantity/rate, pH, buffering capacity
- Plaque: PH, maturity, bacteria – mutans count
- Diet: Number of sugar and acid exposure in between meals/day
- Fluoride: Exposure to fluoride through water or toothpaste or professional treatment
- Modifying factors: Drugs that reduce salivary flow, diseases resulting in dry mouth, fixed or removable appliances, recent active caries, and poor compliance.

The specific threshold values for the data obtained in the analysis of the aforementioned factors are transferred in traffic light color codes conveying varying risk levels (red-high, yellow-moderate, and green-low).[3] The color code model keeps the visual interpretation simple. The objective is to alert the clinician regarding the current risk status and communicable to the patients as well.

6. Recent Advances
Cariometer App
Cariometer app gives an estimate of cariogenic risk of dentition based on daily diet and other oral hygiene practices. Patient should register their details in the app. This app aims in the prevention of dental caries at an early age. It also provides daily cariogenic risk status which can be shared with healthcare professionals [11].

Lactic Acid Impression
Lactic acid impression method is done by using clinpro 3M ESPE which can detect lactic acid which has a main role in fermentation of caries. This impression material consists of a powder, an activator to induce setting and a sugar solution which is metabolised during the 3 minutes of setting. Thus fermentation of sugar and production of lactic acid takes place immediately and there is colour change of the impression material to indicate reaction with lactic acid. Another type of clinpro is Clinpro Cario L-Pop (CCLP) which is used to monitor the individual caries risk [11]. In this technique tongue swab is taken introduced in lactic acid solution and the colour change indicates the level of risk.

Discussion
Caries risk assessment is a concept that is firmly grounded on the well-known fact that dental caries is a preventable disease. CRA tools can be broadly categorized as reasoning-based and algorithm-based tools. In reasoning-based models, important risk factors and indicators are collected in a checklist and the risk is qualitatively assessed. In algorithm-based tools, the risk is quantitatively calculated to improve the objectivity and diagnostic accuracy [12]. Currently, the widely researched reasoning-based risk assessment tools available are CAMBRA [13], tools devised by ADA and AAPD. Cariogram is a popular computerized, algorithm-based program, which analyzes the combination of risk factors in a weighted manner and project the likelihood of avoiding development of new lesions in percentage [14].

The ideal prerequisite of a CRA, as described by Stamm *et al.* [15] is that "To be useful, a working caries prediction model should produce a sensitivity level of 0.75 or higher and specificity level of at least 0.85 or higher." They further elaborated that "any model, regardless of its ultimate accuracy, would have to be based on a data collection system that is relatively quick, inexpensive, requires a limited armamentarium, and be acceptable to those to whom it is applied [16]." General perception among the clinicians or learners about CRA process is that obtaining data is a lengthy process. Collection of wholesome data on all the causative and noncausative variables as discussed above would indeed make an accurate tool, but tends to make the process anything but quick. Thus, recent studies have been conducted on the diagnostic accuracy of few/single predictor factors against analysis of multiple factors. It has been stated that the presence of clinical indicators, namely, carious lesions, restorations or missing teeth, termed together as "past caries experience," has a good predictor capability even as a single factor [17]. But it should be emphasized here that these are only indicators for an established disease in the patient, which is not adequate to achieve the goal of predicting and preventing the disease before it even occurs.

Domejean-Orliaguet *et al.*, [18] while studying CRA in an educational environment, concluded that payment for bacterial assessment is one of the barriers to successful implementation. Gao *et al.* [12] had devised and proposed a questionnaire model for children, and assessed the caries prediction with and without the biological tests, concluded with a logical suggestion that the initial "screening model" without the microbiological test be used for identifying the potential high-risk patients, and later the risk can be assessed accurately for specific clinical decisions, with a "full-blown model" that included those tests.

Exhaustive reviews have concluded that consistent evidence is lacking in terms of good longitudinal prospective studies supporting any of the recent Caries Risk Assessment tools to possess such a dependable accuracy [19]. This makes it difficult to choose the correct one for clinical use. More importantly, it was observed that a tool constructed for a specific population taking into cognizance the baseline caries risk/prevalence of the population has better outcome and accuracy, compared with the same tool being used for a different population. In addition, the subjectivity around the interpretation of data and the way high risk or low risk has been defined by each tool have also been pointed out as reasons for weakness of evidence. In the current scenario, the algorithm-based Caries Risk Assessment systems that evaluate the factors in a "weighted way" are claimed to be more objective and possess better accuracy [20]. However, the interpretation of the data still seems to have profound influence on the diagnostic accuracy and this aspect is intricately woven in all the Caries Risk Assessment tools [19].

Conclusion
Caries risk assessment is the critical component of dental caries management and should be considered a standard of care and included as part of the dental examination. It is not indeed difficult to understand that the CRA as an important step toward caries management, but it is not yet into the mainstream of education or practice, not because the current CRA tools are ineffective, it is just that the mounting evidences are still "not sufficient" enough given the complexity of the disease itself. To make it effective, with available evidence, it is essential that a given CRA tool be adapted to suit the local population needs and preferences. Especially for a country as diverse as India, with wide spectrum in culture, socioeconomic status, food habits, oral hygiene habits, and caries prevalence, this local adaptation assumes a paramount significance. The lack of sufficient robust evidence can easily be overcome by further good-quality, longitudinal prospective studies in the specific population for which the tool is devised. Using a risk assessment provides cost-effectiveness and greater success in treatment compared with the more traditional approach of applying identical treatments to all patients, independent of their risk [13]. Although Caries Risk Assessment utilization rates are low among general dentists, with continued development of supporting evidence and guidelines Caries Risk Assessment will increasingly become the accepted standard of care.

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