CAMBRA Comes of Age
Results From a Practice-Based Research Network Study

Peter Rechmann, DMD, PhD
An Updated CAMBRA* Caries Risk Assessment Tool for Ages 0 to 5 Years

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ABSTRACT This paper provides a practical caries risk assessment (CRA) tool for use by the clinician in caries management by risk assessment (CAMBRA) in 0- to 5-year-olds that updates the original tool published in 2007 and reviewed in 2010. This CRA incorporates evidence-based research from recent implementation studies and is the basis of a risk-based disease-management model that targets individual risk factors, as fluoride therapy alone may be insufficient for high-risk patients.

EARLY CHILDHOOD CARIES (ECC) in young children aged 0 to 5 years continues to be a major problem, negatively affecting the well-being, development and growth of children and their families.1,2 Severe cases of ECC are very difficult to manage and are often accompanied by future decay.3–5 Assessment of the risk level for future occurrence of dental caries lesions is an important first step in managing dental caries and monitoring oral health improvement over time. Successful management of ECC requires a risk-based approach to formulate an individualized treatment plan using a chronic disease management model, which aims at targeting the risk factors (biological, environmental and social) that contribute to the establishment and progression of this multifactorial disease. This individualized treatment plan should include behavior/lifestyle modification (for diet improvement,
less sugar intake and plaque control) and nonsurgical caries management,\textsuperscript{6,7} in addition to appropriate restorative work. The caries risk level determines the personalized caries-management approach for each patient. Personalization further takes into consideration the behavioral barriers of the individual child (their level of cooperation for restorative treatment and home oral health care) and the social context of the child and family.

For decades, there have been numerous attempts to provide methodology to predict future dental caries, to assess caries risk and to manage the disease process.\textsuperscript{8–11} There are many publications related to these topics, including those for children aged 0 to 5 years.\textsuperscript{6,7,12,13} It is not the aim of the present paper to review these published works.

The purpose of this paper is to provide an updated, evidence-based, practical CRA tool for use by dental practitioners for young children aged 0 to 5 years. The procedures and philosophy known as caries management by risk assessment and abbreviated to CAMBRA were published in the Journal of the California Dental Association in 2007 for patients aged 6 years through adult\textsuperscript{14,15} as well as for young children aged 0 to 5 years\textsuperscript{6,16} and have been utilized for more than 15 years in the teaching clinics of the University of California, San Francisco, School of Dentistry (UCSF)\textsuperscript{17} and at the University of California, Los Angeles, School of Dentistry pediatric dental clinic as well as several community health centers in California.\textsuperscript{18,19}

**Caries Balance as the Basis for Caries Risk Assessment**

Many papers have contributed to our understanding of the overall mechanism of dental caries and the roles of fluoride and other agents in the management of the disease process.\textsuperscript{20,21} Based upon decades of research on dental caries by many investigators, we proposed the “caries balance” as a clinically oriented way of evaluating the continuum between progression or reversal of caries in the mouth.\textsuperscript{22–25} Driving this continuum is the balance between the biological caries risk factors (pathological factors), which are, primarily, cariogenic (acid-producing) bacteria, fermentable carbohydrates and salivary dysfunction, and protective factors, which are sufficient saliva, antibacterial agents and remineralization that requires calcium, phosphate and fluoride.

**Caries Risk Assessment for Ages 0 to 5: Evidence to Date From UCSF Clinical Outcomes Studies**

Assessment of caries risk for each patient is essential as the basis for the management of dental caries for patients of all ages.\textsuperscript{26,27} Caries risk is the likelihood of the patient having new caries lesions (white spots, cavitated lesions) in the near future. The CAMBRA system has been shown to be highly predictive of future caries in three different studies, totaling more than 20,000 patients, for the age group 6 years through adult and for the age group 0 to 5 years.\textsuperscript{17,28–30} The results of the outcomes studies in the UCSF pediatric dental clinics are summarized here as the basis for the updated CRA that follows.

An evaluation published in 2016 described the importance of individual risk-assessment items in relation to providers’ CRA decisions and clinical outcomes.\textsuperscript{31} This study assessed the relative importance of 17 CRA items, for children aged 6 months to 72 months, in dental provider’s decision-making regarding CRA and in association with clinically evident dental caries at follow-up. At baseline, 3,810 children were assessed and follow-up data were available for 1,315 after four to 36 months. The CRA procedures used to assess low, moderate, high or extreme risk were as published previously by Ramos-Gomez and co-workers.\textsuperscript{6,16,32} Extreme risk was defined as high risk plus hyposalivation. The 17 CRA indicators are listed in **TABLE 1** and can be categorized to align with the American Association of Pediatric Dentistry risk-assessment item types: biological and environmental risk factors, protective factors and clinical indicators. A provider-assigned risk category (low, moderate, high or extreme) was strongly associated with follow-up decay (**FIGURE 1**). There were very few extreme-risk patients (2 percent), so they...
were combined with high-risk patients. **FIGURE 1** also shows similar results for ages 6 through adult CAMBRA CRA for comparison.12 Both studies showed very good assignment of caries risk by multiple providers using the CAMBRA procedures. Of the 17 CRA indicators used in children aged 0 to 5 years, seven were statistically significantly associated with decay at follow-up (**TABLE 1**, **COLUMN 2**). In further assessment of the data using random forest analysis, only four of those seven baseline CRA items were independently associated with follow-up decay (**TABLE 1**, **COLUMN 3**).

Four items were evident — decay, heavy dental plaque, recent restorations and frequent snacking — with baseline evident decay being the strongest predictor.

A subsequent clinical outcomes study in the UCSF pediatric dentistry clinics examined cumulative dental treatment (restorations) over two years in children initially aged 6 months to 72 months in relation to baseline CRA indicators.29 Of 2,188 available patients, 919 had no follow-up exam and 1,260 returned for follow-up. From those, 519 were excluded (treated under general anesthesia or sedation) and the cumulative restorative treatment of the remaining 750 treated in the conventional clinic setting was assessed in the analyses. All patients had a CRA at baseline and risk was assigned according to the published procedures, based upon the provider’s judgment after evaluating the 17 CRA indicators as shown in **TABLE 1**, **COLUMN 1**. Of the 750 children included, at baseline, 21 percent were classified as low risk, 25 percent as moderate, 53 percent as high and 1 percent as extreme. Nearly all children received fluoride varnish (FV) at baseline. Thereafter, high-risk children were intended to receive FV every three to four months (for those who attended follow-up visits) and every six months for moderate-risk children. FV was not indicated for low-risk patients.

Risk category was associated with the cumulative mean number of treated teeth over two years, namely 0.53, 1.02 and 4.47 for low, moderate and high/extreme, respectively. Receiving any treatment was greatest for high/extreme-risk children but not statistically significantly different between low-risk and moderate-risk children. More than 50 percent of the cumulative restorative treatment performed in the high-risk group was done in the first 190 days after assessment, presumably reflecting existing treatment needs at the time of CRA, a time period in which the low- and moderate-risk groups required almost no restorative treatment. The respective increments for low-, moderate- and high/extreme-risk groups from 190 days to two years, which presumably is a better measure of new caries lesions after the initial CRA, were 0.51, 0.89 and 2.11, clearly showing a continuing need for restorations in the high/extreme-risk group in spite of fluoride preventive measures (figure 2 in Chaffee et al.29). As in the previous study, heavy plaque, obvious decay and recent restorations were strongly associated with subsequent decay. Caregiver/sibling decay, low socioeconomic status and bottle use

**TABLE 1**

<table>
<thead>
<tr>
<th>Baseline CRA item</th>
<th>Column 1***</th>
<th>Column 2***</th>
<th>Column 3***</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk indicators</strong></td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
</tr>
<tr>
<td>Low socioeconomic status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequent snacking</td>
<td><strong>YES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiver or sibling has tooth decay</td>
<td><strong>YES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle used that is not water or milk**</td>
<td><strong>YES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle used continually</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle used in bed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special care needs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate saliva flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salivary reducing medications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protective items</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community water fluoridation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinks fluoridated water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brushes daily with fluoride toothpaste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride varnish in past six months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiver uses xylitol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Clinical disease indicators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evident tooth decay or white spots</td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
</tr>
<tr>
<td>Heavy dental plaque on the teeth</td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
</tr>
<tr>
<td>Recently placed restorations (past two years)</td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
<td><strong>YES</strong></td>
</tr>
</tbody>
</table>

**Use of a bottle that contains fluids other than water or milk was significant in a later clinical outcomes study.**29

**CRA items are based upon Ramos-Gomez et al.6,7,16 Column 1 lists the 17 CRA items utilized in these clinics. Column 2 highlights the seven CRA items found statistically significantly related to decay at follow-up (n = 3,810 at baseline; n = 1,315 at follow-up) in Chaffee et al, 2016.31 Column 3 highlights the four CRA items found independently associated with decay at follow-up by random forests analysis in the same study.31
with nonmilk or nonwater were also significantly associated with subsequent decay. However, it should be noted that the use of milk in a bottle overnight and nursing on demand in the presence of cariogenic bacteria provides a prolonged acid challenge that increases the risk for caries and should be strongly discouraged.

The significant associations in the previous two studies form the basis for the updated CRA form presented here. As there was very limited data for the extreme-risk category, this updated version of the CRA will use three risk categories for 0- to 5-year-olds, namely low, moderate and high.

Caries Risk Assessment — Practical Stepwise Guidelines

The following step-by-step guide is for use of the CAMBRA system with young children aged 0 to 5 years. Details are given in the following sections. The updated 0- to 5-year-old CRA procedure (TABLE 2) identifies low, moderate and high risk for this age group. CRA takes place as part of the regular comprehensive or periodical oral exam in the following sequence or in a sequence that suits the workflow of each individual practice or practitioner. The CRA is the basis for formulating an individualized caries management treatment plan. Here are the steps in the process:

1. From the medical, dental and social histories reported, compile relevant data to record in the CRA form (TABLE 2, COLUMNS 2 and 3).
2. Talk to the caregiver (mother or other caregiver) to make sure all questions listed in the CRA form are answered (TABLE 2, COLUMNS 2 and 3). The discussion will include the risk factors and protective factors, leading to the subsequent clinical exam and later to a discussion of self-management goals.
3. Conduct a clinical examination in an age-appropriate way: knee to knee or with the child sitting on their own, ideally with the parent being able to be shown the findings. Start with detecting and recording presence of plaque, ideally with a visible plaque index score (VPI), and showing parents the problem areas. This answers the heavy-plaque question in TABLE 2, COLUMN 2. Follow with a toothbrush prophylaxis to remove debris and clean surfaces for better visualization during the exam, showing parents the proper brushing technique. The use of a flosser for interdental plaque removal, when appropriate, should also be demonstrated.
4. From the intraoral examination, detect and record caries lesions from their earliest stages (white spots, which can be arrested or reversed by remineralization) to advanced caries (cavitation). From radiographical examination (if available depending on the child’s age and cooperation), detect and record radiographic decay.
5. Assess and document the caries risk as low, moderate or high utilizing data from the complete CRA form with data included in Columns 1, 2 and 3 of TABLE 2. The procedure is further described later in this segment and in TABLE 2. With children aged 0 to 5 years, the questions will likely be answered prior to the clinical examination.
6. Produce and document a caries management plan that addresses all the risk factors that may contribute to the development or progression of disease for that specific patient, including lifestyle and behavior modification for caregivers and the child to achieve plaque control and diet improvements.
7. Prescribe and/or provide chemical therapy for the patient that includes fluoride, with or without antibacterial therapy, based upon the caries risk level and the age of the patient. Details are described later in this segment. Consider integrating motivational interviewing principles with caregivers and patients (when age appropriate) to set up achievable goals for home management plans.
8. Develop a restorative treatment plan that takes into consideration age, behavior (cooperation for treatment delivery), health status and social determinants, favoring minimally invasive restorative procedures to conserve tooth structure whenever possible, restoring function and aiming at providing that patient with the means to achieve adequate plaque control.
9. Establish periodicity of recalls and review at intervals appropriate to the caries risk status to continue active surveillance of noncavitated lesions, provide in-office preventive measures and reinforce behavioral changes and adherence to prescribed daily home regimes.
### TABLE 2

**Updated CAMBRA*** Caries Risk Assessment Form for Patients Aged 0 to 5 (January 2019); available in its original form as a patient download at cda.org/CAMBRA4)

<table>
<thead>
<tr>
<th>Caries risk component</th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biological or environmental risk factors</strong>*</td>
<td>Check if Yes**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequent snacking (more than three times daily)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uses bottle/nonspill cup containing liquids other than water or milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother/primary caregiver or sibling has current decay or a recent history of decay (see high-risk description below)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family has low socioeconomic/health literacy status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medications that induce hyposalivation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protective factors</strong> **</td>
<td>Check if Yes**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives in a fluoridated drinking water area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinks fluoridated water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uses fluoride-containing toothpaste at least two times daily — a smear for ages 0–2 years and pea sized for ages 3–6 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has had fluoride varnish applied in the last six months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biological risk factors — clinical exam</strong>*</td>
<td>Check if Yes**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cariogenic bacteria quantity – Not currently available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy plaque on the teeth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disease indicators — clinical exam</strong></td>
<td>Check if Yes**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evident tooth decay or white spots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent restorations in last two years (new patient) or the last year (patient of record)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Final Score:</strong></td>
<td></td>
<td>Column 1 total</td>
<td>Column 2 total</td>
</tr>
<tr>
<td>Yes in column 1: Indicates high risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes in columns 2 and 3: Consider the caries balance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Final Overall Caries Risk Assessment Category</strong></td>
<td>High ☐</td>
<td>Moderate ☐</td>
<td>Low ☐</td>
</tr>
</tbody>
</table>

* Biological and environmental risk factors are split into a) question items, b) clinical exam.
** Check the yes answers in the appropriate column. Shading indicates which column to place the appropriate yes.

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**Determining the caries risk as high, moderate or low (Caries Risk Assessment form continued)**

1. **High risk.** If there is a “yes” in column 1 (one or both disease indicators), the patient is at high risk. Even if there are no “yes” disease indicators the patient can still be at high risk if the risk factors definitively outweigh the protective factors. Mother or caregiver with current or recent dental decay most likely indicates high caries risk for the child. Use the “yes” checks for each of the risk factor and protective factor columns to visualize the caries balance as illustrated below. The balance clearly to the left indicates high caries risk, whereas clearly to the right the risk level is low.

2. **Moderate risk.** If there are no disease indicators and the risk factors and protective factors appear to be balanced, then a moderate caries risk determination is appropriate. If in doubt, move the moderate to a high classification.

3. **Low risk.** If there are no disease indicators, very few or no risk factors and the protective factors prevail, the patient is at low risk.

Any items checked “yes” may also be used as topics to modify behavior or determine additional therapy. Use the following modified caries balance to visualize the overall result and determine the risk level.

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**FIGURE 3.** Instructions for using the caries risk assessment form.
10. Reassess and document the caries risk level at each recall and modify the caries management plan as necessary.

Steps 1–4 comprise the CRA, which informs the development and implementation of a personalized caries management plan. Hence, CAMBRA is a two-phase process involving both CRA and management of caries as a biologically determined, clinical disease. Steps 1, 3 and 4 are familiar elements of any conventional oral examination for this age group and form the basis of the CRA. Step 2 compiles a few simple questions (as listed in the CRA form in Table 2, Columns 2 and 3) to attempt to determine the cause of the ongoing disease or to determine whether it is under control. Those biological risk factors that have been shown to be statistically significantly related to ongoing caries in previous studies are included here.29,31 Table 2 is a ready-to-use CRA form that provides a visual summary of the factors that contribute to the overall caries risk assignment. Instructions for its use and definitions of terms follow here and are briefly summarized in the second page of the form (Figure 3).

Biological and Environmental Risk Factors (Pathological Factors) — Table 2, Column 2

Biological risk factors contribute directly to the initiation or progression of dental caries. They include an assessment of cariogenic bacteria and fermentable carbohydrates, the two required conditions for dental caries.21–23,33 Additional factors such as frequency of ingestion of fermentable carbohydrates and salivary-reducing medications have been established as important (Table 1). The following are the risk factors utilized in the updated CRA form.

1. Frequent snacking on fermentable carbohydrates at least three times daily outside of meal times.

Frequent carbohydrate intake results in a prolonged acidic environment in the plaque that dissolves the tooth mineral and can act as a driving force to reinforce the overgrowth of cariogenic bacteria and the suppression of oral commensal (beneficial) bacteria, leading to future caries development.34 Fermentable carbohydrates such as sucrose, fructose (high-fructose corn syrup), glucose and cooked starch are included. Fruit juice (e.g., apple juice) is an important but often overlooked source of fermentable carbohydrates among young children.

2. Use of bottle or nonspill cup containing liquids other than water or milk.

This provides a continuous ingestion of carbohydrates, such as from fruit juices, that leads to a continual acid environment in the plaque. It should be stressed that the use of milk in a bottle overnight and nursing on demand in the presence of cariogenic bacteria provide a prolonged acid challenge that increases the risk for caries and should be strongly discouraged.

3. Mother/primary caregiver or sibling has current decay or a recent history of decay.

Presence of recent decay indicates they have high levels of cariogenic bacteria, especially mutans streptococci (MS), which can be transmitted to the child. Early colonization of MS by age 3 will increase the child’s risk for developing caries.34,35 Current or recent decay in the parent or caregiver is an important indicator of potential high caries risk for the child. This becomes more important in infants with few teeth present, where signs of additional risk factors are not yet evident, and is supported by the strong correlation found in numerous studies.36–39

4. Family has low socioeconomic health literacy status.

Low socioeconomic status cannot usually be changed and is not a biological contributor to the caries process. However, as a social determinant of health for many other diseases, it is one of several statistically significant factors associated with high caries risk.29,31 Practitioners should account for a challenging family socioeconomic context in formulating a personalized caries management plan. Similarly, low health literacy is not a biological risk factor, but it is often associated with socioeconomic levels and contributes to increased risk of disease. Importantly, it is possible to educate the parent/primary caregiver regarding caries and caries prevention.

5. Use of medications that induce hyposalivation.

Hyposalivation is a side effect of some of the most commonly prescribed medications, such as those used to treat allergies, asthma, mental disorders and cancer.40 The risk of dry mouth increases with the number of medications prescribed.

In the risk-assessment procedure, any items on this list with a positive response are marked with a “yes” (Table 2, Column 2). Each yes adds to the risk level. Items 1 and 2 can be modified by behavioral management. A yes to item 3 may indicate a potentially very-high-risk patient who requires additional care and therapy.

Protective Factors — Table 2, Column 3

Protective factors are environmental factors or chemical therapy that help to swing the caries balance to caries prevention or reversal. The factors included in the newly proposed CRA form are:

1. Lives in a fluoridated drinking water area.

2. Drinks fluoridated water.

The beneficial effect of drinking fluoridated water is well established.

3. Uses a fluoride-containing toothpaste at least twice daily.

The beneficial effect of brushing...
with fluoridated toothpaste has been well established in numerous clinical trials and is a major factor in reductions in caries over recent decades.\textsuperscript{41–44} The American Academy of Pediatric Dentistry (AAPD) recommends the use of a smear of fluoride toothpaste for ages 0 to 2 years and a pea-sized application for ages 3 to 6 years. For children aged 0 to 6 years, it is recommended that the parent/caregiver brushes the child’s teeth or supervises toothbrushing twice a day. Parent-supervised toothbrushing with fluoride toothpaste at least twice daily provides considerable added benefit greater than once daily.\textsuperscript{45,46}

4. Has had FV applied in the last six months.

The caries-reducing benefit of FV is well established, including when used in young children.\textsuperscript{47,48}

Each of these items with a positive response receives a yes score in TABLE 2, COLUMN 3.

Note: Xylitol use by the caregiver is no longer listed as a protective factor in this revised CRA version as the evidence of its antimicrobial effects to achieve caries prevention is limited for adults or children.\textsuperscript{49}

Biological Risk Factors — Clinical Exam — TABLE 2, Column 2


There is ample evidence that cariogenic bacteria levels are strongly related to caries risk.\textsuperscript{12,50–52} However, at the time of writing there is no validated chairside test commercially available for measuring cariogenic bacterial levels. Therefore, cariogenic bacteria counts have been eliminated from the CRA form in this revised version, although a placeholder has been retained in TABLE 2 to allow for a quantitative bacteria test to be added back at a later date when an evidence-based test becomes available.

2. Heavy plaque on the teeth.

This simple measure, as observed by the clinician, has been shown in our clinical outcomes studies in children of all ages and in adults to be a strong indicator of cariogenic bacterial activity and it is strongly related to ongoing caries.\textsuperscript{17,29–31} This factor may indicate a combination of items that include high levels of cariogenic bacteria, ineffective plaque removal, food accumulation and inadequate brushing with fluoride toothpaste. Gingivitis, or gums that bleed easily, can be a sign of consistent presence of heavy plaque in specific areas and a clinical risk indicator related to the presence of plaque.

In the risk-assessment procedure, any items on this list with a positive response are marked with a yes (TABLE 2, COLUMN 2). Each yes adds to the risk level. Item 2 can be modified by behavioral management.

Disease Indicators — Clinical Exam — TABLE 2, Column 1

This category replaces the “Clinical Indicators” category from the previous CRA form. Heavy plaque on the teeth is not an indicator of disease, but rather is a biological risk factor as described previously and likely indicates high levels of cariogenic bacteria as well as poor oral-hygiene practices. Therefore, it moves to the group of biological risk factors identified in the clinical exam.

Disease indicators are the clinically observed results of previous and/or ongoing dental caries destruction of the tooth mineral. They do not contribute to the disease; they are simply manifestations and clinical signs of the effects of dental caries at different stages. Disease indicators fit into two overall descriptions as evaluated in the outcomes assessments over several years of the original CAMBRA CRA form. They are strong indicators of ongoing disease.

1. Evident tooth decay or white spots. This descriptor includes:
   a. Observed cavitation or radiographic evidence of progression into dentin.
   b. White spot lesions (that are new or active) on smooth surfaces.
   c. Radiographic or visual evidence of noncavitated demineralization into the enamel (usually by bitewing radiographs).

2. Existing restorations.

These are restorations that were placed due to caries in the last two years for a new patient or in the last year for a patient of record. For a new-patient visit, one or more of these disease indicators signals “high caries risk.” For a patient of record at a follow-up visit, any new appearance of indicators 1 or 2 signals “high caries risk.” If present, hyposalivation will require additional care and therapy.

Determining the Caries Risk as Low, Moderate or High

1. High risk. One or more disease indicators signals high risk. Even if there are no “yes” disease indicators, the patient can still be at high risk if the risk factors definitively outweigh the protective factors. Think of the caries balance: Visualize the modified caries balance as shown in FIGURE 3. If the balance is clearly to the left, then the patient is at high caries risk. Mother or primary caregiver with current or recent dental decay most likely indicates high caries risk for the child.

2. Moderate risk. If there are no disease indicators and the risk factors and protective factors appear to be balanced, then neither a high-risk nor a low-
risk assignment is clear. In this case, a moderate determination is appropriate. If in doubt, move the moderate to a high classification.

3. Low risk. If there are no disease indicators, very few or no risk factors and the protective factors prevail, the patient is at low risk. If the balance is clearly swung to the right, the risk level is low. When evidence-based chairside quantitative cariogenic bacteria tests become available, a high cariogenic bacterial count will push a low-caries-risk individual to the high-risk category.

The yes indications are also used to modify behavior or determine additional therapy (as follows).

Caries Management Based on Risk Assessment

CAMBRA therapies for older children and adults place special importance on chemical therapy, because placing restorations can restore tooth form and function but does not affect the risk factors that caused the disease, such as a cariogenic diet or high levels of cariogenic bacteria in the rest of the mouth.6,7,54 The most evident antimicrobial chemical therapy in children aged 6 years and older and in adults is chlorhexidine mouth rinse.17,53 However, use of chemotherapeutic agents in infants and toddlers requires special considerations due to toxicity/safety and behavioral acceptance issues. For this reason, in this age group, most of the recommendations within a caries management plan rely heavily on a chronic-disease management model, where different strategies, such as education about the disease process, motivational interview-style counseling (to change diet practices and plaque-control routines) and periodic evaluation of self-management goals in conjunction with chemical therapy to modify the oral pH environment, are used to target the individual risk factors that can trigger the disease process on the individual patient (frequent snacking, bottle feeding, visible plaque accumulation, etc.)6,7,16 Several publications describe in detail this style of counseling and surveillance.6,7,19,32,55

When addressing oral health in high-risk groups, early intervention and strategic disease management are key. The Disease Management and Risk Assessment module used in the UCLA and UCSF pediatric dentistry curricula stresses the importance of early assessment, diagnosis and intervention as a means of oral disease prevention management.6,7,19,32,55 Early intervention and education are the most effective ways to prevent problems that traditional infectious-disease models fail to address, such as the epidemic of ECC. The UCLA and UCSF module provides pediatric dentistry residents with a background in minimally invasive pediatric dentistry, individual oral health assessment and treatment for pregnant women, infants, children and caregivers. Central to this is the use of the CAMBRA tool, which provides a method of assessing caries risk in young children, thereby informing treatment plans, self-management goals and recall schedules.

In evidence-based minimally invasive dentistry, which includes the use of CAMBRA, fluoride, sealants, remineralization substances such as casein phosphopeptide, prevention of early cariogenic bacteria colonization by xylitol product use for family members with caries and acid-neutralization agents such as baking soda wiping after meals/snacks, the patient/caregiver is encouraged to assume responsibility for the level of infection and is educated, instructed and monitored in the proper control techniques. It is the child who has the disease, but it is the health professional’s responsibility to provide the patient and parent/caregiver the appropriate tools to overcome it.

The following care pathways are summarized in Table 3.

Low-Caries-Risk Management Protocol

If the plaque levels are low as an indication of adequate home care and fluoride exposure has prevented signs of disease under their current dietary conditions, patients should be praised and advised to continue their daily routine. Chemical therapy indicated for infants and toddlers, namely in the form of fluoride toothpaste, must be included in the treatment plan for all patients (even low-risk patients)41 in the appropriate amount (a smear or the size of a grain of rice for children 0 to 2 years and a pea-sized application for 3 to 6 years),42,43 as it is likely to be sufficient to maintain a healthy caries balance in low-risk patients. Fluoride-free “training toothpaste” should not be recommended as its use has not proven to have the same therapeutic effect as full-strength fluoride toothpaste. Recalls for periodic reevaluation should be set for every six months, where their preventive home-care routine should be reinforced. Low-risk
patients do not benefit from in-office fluoride applications.56,57 Radiographic examinations, if necessary (contact areas closed and not visible) and feasible (if patient’s cooperation allows), should be performed at 12- to 24-month intervals as per AAPD and ADA guidelines.58,59

Moderate-Caries-Risk Management Plan

With no signs of caries lesions at any stage, moderate-risk children will present with several risk factors that indicate that their lifestyle routines can lead them to develop caries in the near future and that additional chemical therapy could prevent frequent acid exposure from tipping the balance to the establishment of disease. Caregivers and children (when appropriate) should be informed on the caries process and counseled on strategies to improve their individual dietary or home-care routines. Fluoride-toothpaste recommendations indicated previously should be stressed, additional forms of fluoride exposure (fluoride in drinking water) should be promoted and children at moderate risk should be recalled at six-month intervals for monitoring of adherence to the improvement of diet and home-care routines. These patients will also benefit from in-office FV applications at six-month intervals. Radiographic examinations should be performed every six to 12 months.

High-Caries-Risk Management Plan

Children with obvious signs of caries at any stage and children with several risk factors and minimal fluoride exposure are at high risk of developing more lesions in the future (FIGURE 2). In addition to the chemical therapy (fluoride-toothpaste recommendations and promotion of other forms of fluoride exposure as well as the use of agents that enhance remineralization and acid neutralization or inhibit MS transmission) and behavioral counseling to improve lifestyle changes as mentioned previously, patients at high risk benefit from additional in-office FV applications at three- to six-month intervals. Therefore, three- to six-month recall visits should include FV application, reinforce self-management goals to reduce specific risk factors, promote protective factors and perform active surveillance of lesions at all stages. The caries management plan should include a restorative treatment plan that aims to limit tissue destruction, diminish sensitivity to allow adequate plaque-control measures and restore function and form, taking into account the severity of existing disease.

| TABLE 3 |

Summary of Care Paths for Caries Management Based on Risk for Children Aged 0 to 5 (modified from Ramos-Gomez et al., 2010)7

<table>
<thead>
<tr>
<th>Risk category</th>
<th>Diagnostic</th>
<th>Preventive interventions</th>
<th>Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Periodic oral exams</td>
<td>Radiographs</td>
<td>Fluoride</td>
</tr>
<tr>
<td>Low</td>
<td>6–12 mos</td>
<td>2–24 mos</td>
<td>Brush twice daily with F toothpaste*</td>
</tr>
<tr>
<td>Moderate</td>
<td>6 mos</td>
<td>6–12 mos</td>
<td>Brush twice daily with F toothpaste* optimize F intake* FV every 6 mos</td>
</tr>
<tr>
<td>High</td>
<td>3 mos</td>
<td>6 mos</td>
<td>Brush twice daily with F toothpaste* optimize F intake* FV every 3 mos</td>
</tr>
<tr>
<td>High with extensive existing disease</td>
<td>monthly</td>
<td>6 mos</td>
<td>Brush three times daily with F toothpaste* optimize F intake* FV every 1–3 mos Consider additional therapies for caries control*</td>
</tr>
</tbody>
</table>

¥ Smear of fluoride toothpaste for 0- to 2-year-olds, pea-size of fluoride toothpaste for 3- to 6-year-olds.
£ Recommend drinking fluoridated water (from tap or bottled), parental brushing, spit and don’t rinse toothpaste.
* Wipe with baking soda/xylitol, use casein phosphopeptide — amorphous calcium phosphate (ACP/CPP) paste.
Abbreviations: FV = fluoride varnish; ITR = interim therapeutic restoration; SDF = silver diamine fluoride; mos = months.
consideration the cooperation and health status of the patient as well as the family situation. Following principles of minimally invasive dentistry, the choice of restorative treatment (which is typically needed in high-risk patients) could include traditional restorative treatment or nonsurgical therapies (interim therapeutic restorations with glass ionomer, carries arrest with silver diamine fluoride (SDF), etc.) after careful discussion explaining to the parents the risk and benefits of each option and trying to delay or defer more complicated and risky procedures like sedation and/or general anesthesia. The informed consent of the parent is essential following this discussion and the laying out of recommended options.

High-Risk Patients With Extensive Treatment Needs – Additional Guiding Principles

The outcomes studies described previously show that in-office topical fluoride applications and home fluoride-toothpaste use may not be sufficient to prevent future caries in high-risk patients. A prolonged acidic environment in the plaque created by a frequent sugary/carbohydrate diet and poor oral hygiene leads to microbial dysbiosis and serves as the driving force for caries formation in children, resulting in high caries recurrence in high-risk children. Therefore, home-care behavior modification can be the key to caries management in children.

Children at high risk who already require extensive restorative treatment (more than four restorations, as illustrated in Figure 2B) may benefit from intensive care including protective sealants in surfaces at risk. As studies show that supervised brushing achieves much higher prevention results than brushing alone, supervised brushing should be a major point in the counseling sessions. Brushing three times a day (after every meal) and spitting the toothpaste with no rinsing are simple strategies that may maximize the protective action of fluoride in these children.

Additional possible antimicrobial regimens to consider are wiping/brushing teeth with xylitol and/or baking soda after feedings or meals. Xylitol is noncariogenic and baking soda is an effective acid-neutralizing agent, which can effectively neutralize the oral environment and have antiplaque and antimicrobial effects in children and adults.

For children with numerous cavitated lesions who may need multiple visits to complete restorative care and/or may have limited cooperation for treatment, SDF therapy to achieve carries arrest and desensitization of lesions with no pulpal involvement can be followed at subsequent visits by glass ionomer interim restorations to prevent plaque accumulation and combined with FV at three-month intervals to prevent new lesions. This combination therapy can help to delay or defer more complicated and risky procedures like sedation or treatment under general anesthesia, which is especially important for children under 3 years of age.

Conclusions

Successful management of ECC requires a risk-based approach to formulate an individualized treatment plan using a chronic disease management model, which aims at targeting the risk factors (biological, environmental and social) that contribute to the establishment and progression of this multifactorial disease. This paper provides a practical evidence-based updated CRA tool for the clinician to use in practice for young children aged 0 to 5 years. This updated CRA tool incorporates evidence from recent implementation studies to be used as the basis of such a risk-based caries management treatment plan that aims to restore oral health, as fluoride therapy alone is insufficient for high-risk patients. This approach is considered standard care for children’s oral health.

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