Conference Paper

The Clinical, Environmental, and Behavioral Factors That Foster Early Childhood Caries: Evidence for Caries Risk Assessment

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Abstract: *Caries risk assessment, an essential component of targeted health care delivery for young children, is of paramount importance in the current environment of increasing health care costs and resource constraints. The purpose of this manuscript was to review recent best available evidence behind the factors that influence caries risk assessment and the validity of strategies to assess the caries risk of young children. Moderate to weak evidence supports the following recommendations: (1) Children should have a caries risk assessment done in their first year (or as soon as their first tooth erupts) as part of their overall health assessment, and this should be reassessed periodically over time. (2) Multiple clinical, environmental, and behavioral factors should be considered when assessing caries risk in young children, including factors associated with the primary caregiver. (3) The use of structured forms, although most may not yet be validated, may aid in systematic assessment of multiple caries risk factors and in objective record-keeping. (4) Children from low socioeconomic status groups should be considered at increased risk when developing community preventive programs.* *(Pediatr Dent 2015;37(3):217-25) Received January 23, 2015 Last Revision March 26, 2015 / Accepted April 3, 2015*

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Targeted health care delivery has become paramount in the current environment of increasing health care costs and resource constraints. The management of dental caries is no exception. Early childhood caries (**ECC**) is relatively inexpensive to prevent, yet dental caries is the most prevalent chronic condition among U.S. children and the most common unmet health care need of poor children across the country. If allowed to progress and if left untreated, the disease often has broad dental, medical, social, and quality of life consequences.[1] In addition, there are profound disparities in the impacts of ECC.[2] As much as 80 percent of caries incidence is experienced by only 20 to 25 percent of the population, with children from the lowest socioeconomic groups experiencing caries at significantly higher rates and younger ages.[3] Reports of caries prevalence rates vary by area of the country, with rates ranging from as low as 12 percent to as high as 90 percent in certain vulnerable populations.[4] There are also clear issues related to access to preventive services. In some areas, as few as 25 percent of children saw a dentist in the past year.[5]

The previous challenges have brought about a greater interest in the early and objective identification of children at high caries risk in order to assist in decision-making to appropriately tailor cost-effective interventions and the periodicity of these services. In fact, risk-based, patient-centered decision-making, supported by best available evidence, is an essential component for the correct prevention and management of dental caries,[6,7] especially in young children.[7-9] Caries risk assessment (**CRA**) is defined as the process of establishing the probability of an individual patient to develop new carious lesions over a certain time period[10] and/or the probability that there will be a change in severity and/or activity of currently present lesions.[7] The term caries risk assessment and acronym CRA is sometimes mixed up with caries prediction, which is the statistical modeling of factors related to caries development in defined groups of people. The validity of caries predictors is determined in prospective studies without any intervention, and the outcome is expressed in continuous values (e.g., sensitivity, specificity, area under receiver operating characteristic [**ROC**] curves).[10]

Because of the multifactorial and chronic nature of the dental caries disease process, studies on risk assessment tend to be complex, with multiple influences at the individual, family, and community level challenging the prediction throughout the life of an individual.[8,11] In addition, risk factors may vary based on race, culture, and ethnicity.[12,13] For a clinician, the concepts of assessment of risk and prognosis are an important part of clinical decision-making. In fact, the dentist's overall subjective impression of the patient might have good predictive power for caries risk.[14] However, for monitoring purposes, it is clear than an objective record of risk must be included in the patient's chart.

The list of variables that may directly or indirectly influence caries risk is long, especially in young children,[15-17] and includes: clinical/biological factors (e.g., caries experience of child and caregiver, plaque/microbiology, gingivitis, saliva, tooth developmental defects, medical factors, genetics); environmental factors (e.g., exposure to fluoride, antibiotic usage, exposure to lead); and behavioral/psychosocial/sociodemographic factors (e.g., diet, oral hygiene habits, age, parenting styles, child temperament, beliefs, caregiver's education level, socioeconomic status, insurance status, access to dental care). These variables are then taken to develop a caries risk profile/category (e.g., low risk, moderate risk, high risk). In addition, some of these risk factors not only influence dental caries but have much broader impacts on general health. For example, diet is one of the common risk factors, playing a role in dental caries, obesity, diabetes, heart disease, stroke, and cancers.[18]

There are numerous strategies and tools available for CRA in daily practice, which include an informal assessment, use of structured paper forms, and use of computer-based programs.[10] An informal risk assessment may be carried out in connection

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with a dental examination and is the most common form of risk assessment performed currently in the United States.[19] However, even when an informal risk assessment is performed, data from U.S. adults suggest that this information does not always translate into individualized preventive plans.[20]

Today, there are multiple CRA structured paper forms for different age groups that are being promoted to act as a framework for risk-based treatment decision-making and determine individual recall intervals. Available CRA paper forms are, for the most part, expert-based tools, as none have been validated longitudinally on U.S. children. Examples include the Caries Risk Tool (**CAT**) of the American Academy of Pediatric Dentistry,[15] the American Dental Association's Caries Risk Tool for children younger than six years old,[21] the Caries Management by Risk Assessment (**CAMBRA**) tool for children younger than six years old,[22] and the Dundee Caries Risk Assessment Model.[23] Finally, regarding use of computer-based programs, the Cariogram, a free download software program popular in many countries, is designed to calculate 'the chance to avoid new caries lesions in the near future.'[24] Although the Cariogram may also be useful without bacterial tests, the resulting combined sensitivity/specificity is reduced.[25]

The purpose of this manuscript was to review best available evidence behind the clinical, environmental, and behavioral factors that influence caries risk assessment and the validity of strategies to assess the caries risk of preschool children in order to provide recommendations for risk assessment in practice.

Methods

The primary search was focused on identifying recent systematic reviews and evidence-based recommendations that focused on CRAs or evaluation of caries risk forms for zero- to five-year-old children (inclusion criteria). Reports in the gray literature (theses, etc.), as well as expert opinion reviews, were excluded from the primary search. Databases that were searched, focusing on the English language between 2005 and October 1, 2014, included the Cochrane Database of Systematic Reviews (Cochrane reviews, other reviews, and technology assessments), National Guideline Clearing House, Ovid MEDLINE, and PubMed. MeSH and free terms used included: child preschool; infant; dental caries; caries risk; risk assessment; prediction; practice guidelines; evidence-based recommendation; recommendation; risk factor; caries risk form.

To support the discussion of the systematic review findings, references included in pertinent systematic reviews (and in previous reviews or systematic reviews on CRAs by the author) were also hand searched and used in the discussion. For systematic reviews, essential data on study conclusions, evidence-based recommendations, and risk assessment outcomes (e.g., sensitivity, specificity, area under ROC-curves) were extracted. No formal quality assessments or grading were performed, but if the systematic review or evidence-based recommendation was graded in an included study, this was reported.

The broad search for systematic reviews and evidence-based recommendations identified 311 publications since 2005. After removing duplicates and studies that did not meet the inclusion

Table 1. EXAMPLES OF CONCLUSIONS FROM SYSTEMATIC REVIEWS AND EVIDENCE-BASED RECOMMENDATIONS FOR CARIES RISK ASSESSMENT IN PRESCHOOL CHILDREN (0-5 YEARS OLD): 2007-2014*

Study (year)	Supports multivariate models for caries prediction	Concludes that Cariogram has limited prediction accuracy	Supports previous caries experience as the strongest single predictor	Concludes that other factors have limited accuracy when used alone to predict caries	Rates the quality of the evidence and accuracy of the findings	Includes evidence-based graded recommendations for practice
Swedish Council on Technology Assessment in Health Care (2007)[28]	X		X	X	X	
Tellez et al. (2013)[81]		X			X	
Scottish Intercollegiate Guidelines Network-SIGN (2014)[18]	X		X	X	X	X
Mejàre at al. (2014)[26]	X	X	X	X	X	
Studies of caries risk assessment performed by medical primary care clinicians						
Chou et al. (2014)[82]	No studies available to review				X	
Moyer (2014)[27]	No studies available to review				X	X (USPSTF recommendations)
Studies on risk assessment focused on mutans streptococci (MS)						
Thenisch et al. (2006)[64]	Concludes that, although MS appears associated with an increase in risk in caries-free children, lack of adjustment for confounders limits the interpretation of the result					
Parisotto et al. (2010)[65]	MS is a strong risk factor for caries risk indicators, but longitudinal studies are needed to confirm its role as a predictive risk factor					

* MS=mutans streptococci; USPSTF=U.S. Preventive Services Task Force.

criteria, 12 publications were finally included (cited in Tables 1 to 4, plus Leong et al.[66] and Chou et al.[47]). Greater weight was given to systematic reviews and recommendations published in 2013 and 2014 following well-described search and evidence-grading methodology (e.g., the Scottish Intercollegiate Guidelines Network [**SIGN**],[18] Mejàre et al.[26])

For example, SIGN recently published evidence-based guidelines for caries management in children.[18] They conducted a systematic review of clinical studies between 2000 and 2011 using databases (Medline, Embase, Cinahl, PsycINFO, and the Cochrane Library) and various websites (e.g., U.S. National Guidelines Clearinghouse), and the main searches were supplemented by material identified by the authors. Selected manuscripts were evaluated using standard SIGN methodological checklists and grading of the evidence (Table 2).

Another example used in this manuscript includes findings from the U.S. Preventive Services Task Force's (**USPSTF**) recently published evidence-based recommendations for caries prevention in zero- to five-year-olds targeted to nondental health care personnel.[27] They searched the Cochrane Register of Controlled Trials and Cochrane Database of Systematic Reviews (through the first quarter of 2013), searched Medline (1999 through March 8, 2013), and manually reviewed reference lists. Only English-language randomized and nonrandomized trials were included.

Results and Discussion

Very few high-quality, longitudinal caries risk studies exist that focus on infants and toddlers.[8,26,28,29] In addition, very few quality systematic reviews have looked at risk assessment and/or provided evidence-based recommendations for young children (Table 1). Existing studies have been conducted primarily in selective populations in Europe[30-36] or Asia,[29-37,38] with a limited number of studies conducted in the United States.[12,39,40] Furthermore, the prediction models have not been validated in independent populations, thereby diminishing the generalizability of their results. According to Mejàre et al.,[26] for schoolchildren and adolescents, only one study was identified where the model had been validated in another population; it showed that the sensitivity differed considerably when applied to another population.[41]

Multivariate variable models. Together, existing studies suggest that: (1) the possibilities to correctly identify preschool children at risk of caries are relatively high; and (2) additional factors related to caries experience are associated with caries progression and may increase the accuracy of prediction when applied to very young children. However, presence of these factors individually is not necessarily predictive of dental caries (evidence grade equals 2++, SIGN[18]; Table 2). The use of multivariate risk models has generally proven more accurate than using few or single factors, which seems particularly true in preschool children.[26] Data obtained using a structured parental interview suggest that caries prediction in young children may be possible without the necessity of an oral examination.[12,42] A risk factor model comprising 10 demographic variables (exposure to water fluoridation, environmental smoke exposure, tobacco use, race, gender, age, urban versus rural local, body mass index, insurance status, and sealant application) was validated for future caries over six years in a public health setting, resulting in a sensitivity and specificity of 79 percent and 81 percent, respectively.[42]

In a prospective study in Singapore, a sensitivity and specificity of 0.9 in 3- to 6-year-olds was achieved when a questionnaire, oral examination, and salivary tests were combined to predict a one-year caries increment.[29] In this study, a sensitivity/specificity of 0.82/0.81 was achieved when using only multivariate data derived from a questionnaire. At one year of age, a combination of sociodemographic factors (immigrant status, measured as language spoken at home; mother's education), dietary habits (consumption of more than one piece of candy per week; consumption of sugared beverages greater than twice a day) and mutans streptococci counts in a low socioeconomic immigrant area in Sweden gave a sensitivity and specificity sum of 170 percent.[31] A follow-up analysis in the same children at 2.5 years old showed, however, that the presence of carious lesions was the single best predictor as the child aged.[32] In another study of Finnish toddlers, the greatest precision in prediction was achieved by a combination of history of caries, dietary habits (candy consumption), and mutans streptococci (sensitivity/specificity of 0.69/0.78).[35]

In a systematic review, Zero et al.[9] concluded that the best predictor for caries in primary teeth was previous caries experience, followed by level of parental education,[30] and socioeconomic status.[43] They concluded that: (1) many models included similar categories of risk indicators but provided different outcomes, depending on the study population; (2) in many instances, the use of a single risk indicator gave equally good results as the use of a combination of indicators; (3) no combination of risk indicators was consistently considered a good predictor when applied to different countries, across different age groups; (4) however, in general, the best indicators of caries risk, especially in young children, were easily obtained from interviewing parents and did not require additional testing.

Previous caries experience. Previous or current caries experience summarizes the cumulative effect of all risk factors and protective factors to which an individual has been exposed over a lifetime. Children with previous caries experience are at increased risk of future caries[26,31,44-46] (evidence grade equals 2++[18]). Use of previous caries experience might also be a useful predictor when used by nondental personnel. For example, a recent systematic review[47] found a good-quality study of primary care pediatricians' examination of children younger than 36 months old was associated with a sensitivity of 0.76 for identifying a child with one or more cavities and 0.98 for identifying children who needed a dental referral.[48] Another study found that pediatrician examinations resulted in a sensitivity/specificity of 1.0/0.87 for identifying caries involving one or more of the primary maxillary central or lateral incisors or the primary molars, but excluding the primary mandibular incisors, in 18- to 36-month-olds.[49]

Microbiological risk factors. Dental caries is a microbial disease in which the etiological agents are normal constituents of the oral biofilm that cause problems only when their pathogenicity and proportions change in response to environmental conditions. The presence of mutans streptococci or lactobacilli in saliva or plaque as a sole predictor for caries in the primary dentition has showed low accuracy.[50] One of the reasons might be that the methods used do not properly best reflect the biolfilm's cariogenic activity, and/or that a high level of mutans streptococci may be partly compensated by other factors, such as good oral hygiene and a noncariogenic diet.[51] However, their presence in saliva contributes to the accuracy of some multivariate prediction models in preschoolers.[26,37] Thus, caries

Table 2. ACCURACY AND STRENGTH OF THE EVIDENCE FOR RISK FACTORS THAT ELEVATE CARIES RISK IN PRESCHOOL CHILDREN (0-5 YEARS OLD), BASED ON 2014 REVIEWS

Risk factor	Accuracy	Quality/strength of evidence	
	Source (study year) and details on how accuracy or evidence was graded		
	Mejàre at al. (2014)[26a*]	Mejàre at al. (2014)[26b†]	Scottish Intercollegiate Guidelines Network-SIGN (2014)[18c‡]
Multivariate prediction models (excluding Cariogram)	Moderate/good (but most not validated in independent population) Best models: Se >0.80; Sp >0.70	Limited	Multiple risk factors involved: 2++ Dentists' subjective judgment of new lesions over time: 2+ No consensus as to which tool is most effective: 3
Cariogram	Limited Se=0.46-0.71; Sp=0.66-0.88	Limited	No consensus as to which tool is most effective: 3
Presence of previous caries experience	Moderate/good Sen=0.29-0.78; spec=0.72-0.97 Odds ratio=2.2-13.5 Relative risk/hazard ratio=2.3-3	Limited	One of the most important risk indicators: 2++
High levels of mutans streptococci	Poor Se=0.13-0.69; Sp=0.78-0.97 Odds ratio=3.2-3.9; hazard ratio=4.1-7.6 (high specificity)	Limited	One of the most important risk indicators: 2++
Low socioeconomic status (SES, including belonging to a minority race/ethnicity)	Limited/poor immigrant background: Se=0.77; Sp=0.59 Odds ratio=3.4 Parents education: Se=0.69; Sp=0.57	Limited	Caries more prevalent in children from low SES: 2++
Presence of developmental tooth defects/low birthweight		Weak	More research is required in this area before conclusions can be drawn: 2++
Salivary problems (buffer capacity, urease)	Salivary buffer capacity of no predictive value Increasing urease: hazard ratio=4.98	Limited	Generally not helpful to assess risk: 4
Problems with oral hygiene/use of fluoride	Poor Se=0.55-0.59; Sp=0.63	Limited	
Diet (frequent sugar exposure), including factors related to inappropriate breast- and bottle-feeding	Poor Candies >1/wk: Se=0.72-0.84; Sp=0.45-0.55 Odds ratio=1.5-2.3 No sugar at night: odds ratio (to avoid caries)=24	Limited	
Maternal and family associated factors (e.g., caries experience, low socioeconomic status, frequent snacking, lack of knowledge about oral health, etc.)			Parental deprivation is a risk indicator for caries in their children: 3 All other maternal factors not proven helpful as predictive indicators yet: 2+
Posteruptive age	Insufficient evidence	Insufficient evidence	

* a: evidence graded according to the sum of sensitivity (Se) and specificity (Sp): moderate/good= >1.5; limited= <1.5 but >1.3; poor= <1.3.
† b: high=based on high/moderate quality studies containing no factors that weaken the overall judgment; moderate=based on high/moderate quality studies containing isolated factors that weaken the overall judgment; limited=based on high/moderate quality studies containing factors that weaken the overall judgment; insufficient=scientific evidence is lacking, quality of available studies is poor, or studies of similar quality are contradictory.
‡ c: 1++, 1+, and 1- =evidence is derived from meta-analyses, systematic reviews, or randomized clinical trials with very low, low, or high risk of bias; 2++ =evidence is derived from high quality systematic reviews of case control/cohort studies, or evidence derived from high quality case control/cohort studies with a very low risk of bias and high probability that the relationship is causal; 2+ =well-conducted case control/cohort studies with a low risk of bias and moderate probability that the relationship is causal; 2- =case control/cohort studies with a high risk of bias and significant risk that the relationship is not causal; 3=nonanalytic studies (e.g., case reports); 4=expert opinion.

in young children is associated with high oral levels of mutans streptococci[52-58] (evidence grade equals 2++[18]); together with caries experience, this is one of the most important risk factors identified in young children.[14,31,35,45,46,59-63]

In a 2006 systematic review, the presence of mutans streptococci in the plaque and saliva of young caries-free children was also associated with a considerable increase in caries risk; however, the lack of adjustment for confounders might limit the extent to which this finding can be extrapolated to practice.[64] A 2010 review also supported the use of mutans streptococci as a strong risk indicator for caries in young children.[65] A recent study found that when mutans streptococci and lactobacilli levels were added into a biopsychosociobehavioral model for ECC, it slightly improved the prediction, regardless of whether past caries experience was (sensitivity/specificity equals 81 percent/85 percent) or was not (85 percent/80 percent) incorporated into the model (Table 3).[37] A recent systematic review concluded that, although multiple maternal factors (e.g., high levels of cariogenic bacteria) were identified to influence bacterial acquisition in young children, and colonization appeared mediated by some oral health behaviors and feeding habits, a relationship between these factors and subsequent caries was still not clear.[66]

Sociodemographic and dietary risk factors. Sociodemographic variables are included in several multivariate models tested to assess caries risk in preschool children, with immigrant status and parents' education/beliefs being significant in several studies.[26,30,31] As reviewed recently by SIGN,[18] children living in low socioeconomic status families and/or high deprivation areas have significantly more caries than those from high socioeconomic areas[38,67] (evidence grade equals 2++). In addition, it was concluded that no relationship has been demonstrated between low birth weight and caries development.[68] One of the studies included in the SIGN review showed that low birth weight could be associated with enamel defects and caries in the primary dentition,[69] but more longitudinal research is required before conclusions can be drawn (evidence grade equals 2++). The very few longitudinal studies that focus on the relationship between enamel defects and caries risk suggest that enamel hypoplasia is a significant risk factor for caries and should be considered in CRAs.[70,71]

Sugar exposure is an important etiologic factor in caries development. Because of the wide use of fluoride and its effect in lowering the incidence and rate of caries, it is difficult today to show a strong positive association between total sugar consumption and caries development. In a recent systematic review, the odds ratio for assessment of dietary habits and attitudes toward diet for prediction of caries in preschoolers was moderate to low (1.5 to 3.6), with poor accuracy.[26] However, in preschool children, dietary habits as a single risk factor were statistically significant in univariate analysis in several studies, probably because exposure to fluoride in this age group tends to be limited; however, the accuracy was still poor.[26]

Saliva. Saliva plays an important role in the health of soft and hard tissues in the oral cavity. Dentists can assess several salivary parameters related to caries risk, but the most common ones include salivary flow rate, buffering capacity, and pH.[72] Although decreased salivary flow rate tends to be a problem more common in adults than children, a small proportion of children may have reduced salivary flow,

Table 3. ROLE OF MICROBIAL FACTORS IN CARIES RISK PREDICTION (BASED ON DATA FROM GAO ET AL., 2013)[37]*

Variable	Sensitivity (%) for Ddmft>0	Specificity (%) for Ddmft>0	Accuracy	AUC
MS (Dentocult score >2)	79	67	72	NA
LB (Dentocult score >2)	51	89	71	NA
MS+LB	66	85	77	0.82
Past caries	70	83	77	NA
Past caries+MS	81	77	79	0.84
MS+LB+past caries	80	80	80	0.85
Multifactorial screening model (sociodemographic; oral habits; oral hygiene; caries)[29]	82	73	77	0.85
Multifactorial screening model without caries	75	76	75	0.80
Multifactorial model+MS+LB	81	85	83	0.90
Multifactorial model+MS+LB without caries	85	80	82	0.89

* A total of 1,576 3-5 year olds in Singapore were followed for 1 year. Microbial data was collected using Dentocult (MS=mutans streptococci; LB=lactobacilli); dmft=decayed, missing, and filled primary teeth.

Table 4. COMPARISON OF CARIES RISK TOOLS IN PREDICTING CARIES IN YOUNG CHILDREN IN HONG KONG (BASED ON GAO ET AL., 2013)[38]*

Caries risk tool (risk threshold)	Sensitivity (%) for Δdmft>0	Specificity (%) for Δdmft>0	Accuracy
CAT screening (> high)	99	5	40
CAT with salivary/microbiological test (> high)	100	4	39
CAMBRA screening (> moderate)	97	21	49
CAMBRA screening (> high)	94	44	62
CAMBRA with salivary/microbiological test (>moderate)	92	40	59
CAMBRA with salivary/microbiological test (> high)	84	63	71
Cariogram screening (algorithms) (> 38.5% change of caries)	63	78	73
Cariogram with microbiological test (algorithms) (> 37.6% change of caries)	65	79	74
NUS-CRA screening (algorithms) (> 32.8% change of caries)	74	85	81
NUS-CRA with microbiological test (algorithms) (> 35.2% change of caries)	78	85	83

* CRA=caries risk assessment; CAT=caries risk tool of the American Academy of Pediatric Dentistry[15]; CAMBRA=Caries Management by Risk Assessment (CAMBRA) tool for children younger than 6 years old[22]; NUS=model proposed by Gao et al. in 2013 (called the National University of Singapore model-NUS)[29]; dmft=decayed, missing, and filled primary teeth.

usually as a consequence of their medical history and related medications. Despite the association between low salivary flow and caries, salivary markers have generally proved unhelpful in the formal assessment of caries risk in the 0-5 year old age group [18,73,74] (evidence grade equals 4[18]).

Influence of parental oral health status. Because of the multiple influences at the individual-family-community level in the development of ECC,[11] parental factors associated with CRAs in young children have been the focus of extensive research. A recent review by SIGN[18] concluded that parental deprivation was a risk indicator for caries development in their children[14,53] (evidence grade equals 3), but the presence of maternal active carious lesions, high levels of oral mutans streptococci, or reported high sucrose consumption has not been proven to be predictive indicators of caries risk in children[75] (evidence grade equals 2+). The SIGN[18] review included articles up to 2011. Since then, there have been several longitudinal or large cohort studies showing an association between material risk factors and caries in their children. For example, a recent study showed that mothers of ECC children had significantly lower prenatal concentrations of vitamin D than mothers of caries-free children.[76] Maternal weight and intake of sugar and fat in pregnancy were associated with caries experience in preschool children.[77] Maternal salivary bacterial challenge not only was associated with oral infection among children but also predicted increased ECC occurrence.[78] Compared to children delivered by Caesarean section, vaginally born children experienced increased ECC prevalence and were more likely to have higher MS scores.[79] Mothers' oral health status was a strong predictor of the oral health status of their children, with a similar relationship observed between mothers' tooth loss and caries experience among their children.[80]

Assessment of caries risk forms/programs/tools. Even when there is evidence that the development of a generalizable CRA tool for preschool children is feasible[18,23] (and there are many CRA tools in existence), the evidence offers no consensus as to which tool is more effective; in addition, their validity is still very limited.[81] SIGN[18] found no evidence that the use of a CRA tool results in enhanced caries prevention for at-risk groups (evidence grade equals 3). Furthermore, the USPSTF concluded there are no validated multivariate screening tools to determine which children are at higher risk for dental caries, especially when used in the primary care setting.[27,82] On the other hand, the Cariogram has been successfully validated in numerous prospective longitudinal studies in schoolchildren[83,84] but has been found less useful in younger preschool children.[10,29,81,85] The sensitivity and specificity for schoolchildren has been reported to be between 73 to 83 percent and 66 to 85 percent, respectively.[28,84]

Yet, it can be argued that, when the well-being of the young child is considered, it is more important to carry out a risk assessment incorporating best available evidence than making no attempt due to lack of consensus and firm evidence on which form to use.[8,10,72] In preschool children, although there is no clearly superior method for predicting future caries, the use of structured protocols combining sociodemographic factors, previous caries experience, and etiologic factors (e.g., diet, oral hygiene routines) resulted in moderate to good accuracy, with sensitivity greater than 80 percent and specificity exceeding 70 percent.[26] Interestingly, although most reviews on CRAs conclude that a CRA is still limited because it is more effective in the selection of low-risk versus high-risk patients,[8,26,28] this limitation might be useful in some population groups to screen out low-risk patients so that resources can be given to those with the greatest need.[10,86] In fact, a recent study of 544 three-year olds followed for one year in Hong Kong compared the accuracy for caries prediction of several risk tools (Table 4),[38] including CAT,[15] CAMBRA,[22] Cariogram,[24] and the National University of Singapore model (**NUS**) proposed by Gao et al.[29] They concluded that the CAT and CAMBRA tools with and without salivary/microbial factors included had low specificities (range equals five to 63) but high sensitivities (range equals 84 to 100), while the Cariogram and NUS model had higher specificities (range equals 78 to 85) and sensitivities (range equals 63 to 78) when used in this population.

Conclusions

Based on this study's findings, the following conclusions and recommendations, slightly modified from those provided by the Scottish Intercollegiate Guidelines Network,[18] can be made:

1. Health care professionals (and certainly dental professionals) should carry out a caries risk assessment of children in their first year (or as soon as their first tooth erupts[15]) as part of the child's overall health assessment (recommendation grade level is D, per SIGN[18]); this should be reassessed periodically over time. A child considered to be at risk for caries should be referred to the appropriate health service provider for follow-up care.
2. Multiple clinical, environmental, and behavioral factors should be considered when assessing caries risk in young children (recommendation grade level is C, per SIGN[18]), and many of these are easily attainable by interviewing parents. Examples include: caries experience; dietary habits, especially frequency of sugary food and drink consumption; social history, particularly socioeconomic status; oral hygiene habits, including use of fluorides; and medical history, with emphasis on conditions that could affect salivary flow rate. Furthermore, when assessing the caries risk of very young children, it is important to consider not only factors associated with the child but also the parent/primary caregiver (e.g., parental oral health status and parental deprivation).
3. The use of structured forms, although with limited validity, may aid in the systematic assessment of multiple caries risk factors in practice and aid in objective record-keeping over time (recommendation grade level is D). More research is needed to validate multivariate models for risk assessment, outcomes of their use by dental and nondental health care providers, and their validity across different population groups.
4. Children from low socioeconomic status groups should be considered at increased risk of early childhood caries when developing community preventive programs (recommendation grade level is D, per SIGN[18]).

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