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Validation of an early childhood caries risk assessment tool in a low-income Hispanic population

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Abstract

Objectives—There is a recognized need for valid risk assessment tools for use by both dental and nondental personnel to identify young children at risk for, or with, precavitated stages of early childhood caries (i.e., early stage decalcifications or white spot lesions). The aim of this study is to establish concurrent criterion validity of “MySmileBuddy” (MSB), a novel technology-assisted ECC risk assessment and behavioral intervention tool against four measures of ECC activity: semi-quantitative assays of salivary mutans streptococci levels, visible quantity of dental plaque, visual evidence of enamel decalcifications, and cavitation status (none, ECC, severe ECC).

Methods—One hundred eight children 2-6 years of age presenting to a pediatric dental clinic were recruited from a predominantly Spanish-speaking, low-income, urban population. All children received a comprehensive oral examination and saliva culture for assessment of ECC indicators. Their caregivers completed the iPad-based MSB assessment in its entirety (15-20 minutes). MSB calculated both diet and comprehensive ECC risk scores. Associations between all variables were determined using ordinal logistic regression.

Results—MSB diet risk scores were significantly positively associated with salivary mutans ($P < 0.05$), and approached significance with visible plaque levels ($P < 0.1$). MSB comprehensive risk scores were significantly associated with both oral mutans and visible plaque ($P < 0.05$). Neither was associated with visually evident decalcifications or cavitations.

Conclusions—Findings suggest that MSB may have clinical utility as a valid risk assessment tool for identifying children with early precursors of cavitations but does not add value in identifying children with extant lesions.

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Keywords

diet; dental caries; minority health; nutrition assessment; risk assessment; early childhood caries; pediatrics

Introduction

Early childhood caries (ECC) is a highly prevalent, disparately distributed, and consequential oral condition of children under age six years. It progresses with age – affecting an estimated one in 10 2-year-olds (11 percent) and increasing to nearly half of 5-year-olds (44 percent) (1). It disproportionately impacts low income, minority, and immigrant children (1-6) and is associated with acute presentations, impaired growth and development, diminished self-esteem and quality of life, and elevated risk for caries in the permanent dentition (7-12). Dental cavities resulting from ECC are often repaired under general anesthesia in operating room settings at high expense and stress on children and families and low long-term impact on disease progression, evidenced by reported 2-year cavity recurrence rates of 53-79 percent (13-18). As dental repair does not address the underlying disease process that results in cavitations (10), the American Academy of Pediatric Dentistry (AAPD) (19,20) and other caries authorities (21,22) have advanced early preventive interventions predicated on differential risk and disease management protocols that suppress cariogenesis. In order to be effective, risk-based disease management protocols must target the primary drivers of ECC: diet-and fluoride-related behaviors. There is a recognized need in the oral health community for more valid and reliable risk-assessment tools and intervention strategies that are both economical and clinically feasible (20,21).

In response to this need, a multidisciplinary Columbia University team of health professionals (pediatricians, dentists, and nurses), helping professionals (social workers, dietitians, and community health workers), and educational technologists with support from the National Institute on Minority Health and Health Disparities (RC1MD004258) developed “MySmileBuddy” (MSB), a novel risk assessment, caregiver education, and ECC management tool. The MSB tool is designed to assess a child’s ECC risk by collecting data regarding a child’s exposure to etiologic risk factors (e.g., cariogenic feeding practices, inadequate fluoride use, and history of disease). Additionally, MSB is designed to facilitate disease management counseling with caregivers of at-risk children by providing targeted recommendations for goal setting based on a child’s reported behavioral risk factors. The MSB tool is also culturally, linguistically, and visually customized for the low-income, primarily Hispanic population served by the University’s postdoctoral Pediatric Dentistry Clinic.

The MSB tool provides a more comprehensive assessment of risk than previously developed tools (e.g., CAMBRA, AAPD CAT) by including measures related to diet and feeding practices, caregiver attitudes and beliefs, fluoride use, and family history (23). The Diet and Early Childhood Caries (DECC) Study was designed to validate this comprehensive tool in aggregate as well as its dietary component independently. The dietary component was singled out because of the long-standing recognition that frequent consumption of cariogenic

foods and beverages is a significant risk factor and because dental professionals rarely assess patients' diet-related behaviors adequately (24-27). MSB assesses dietary factors both through interactive questions raised by the iPad-based program, in discussions between caregivers and lay or professional counselors, and through a widget designed to capture a modified 24-hour dietary recall (23).

The primary aim of the DECC study was to establish concurrent criterion validity of MSB's risk tool both for its *comprehensive* and its *diet* risk scores with four measures of ECC activity: a) semi-quantitative assays of salivary mutans streptococci levels; b) visual evidence of enamel decalcifications on all surfaces; c) visible quantity of dental plaque on the four maxillary incisors; and d) presence of frank cavitations.

Methods

DECC is a cross-sectional component of the Bio-Behavioral Chronic Disease Management by Families of Young Minority Children Study which developed and piloted MSB (23). The DECC protocol was approved by the Teachers College of Columbia University and Columbia University Medical Center Institutional Review Boards, and written consent was obtained from all participants.

Caregiver/child dyads presenting to the Columbia University College of Dental Medicine Pediatric Dental Clinic for new or recall dental examinations between August 2012 and January 2013, on days when one of four standardized investigators were present, were targeted for recruitment. All investigators were bilingual in Spanish and English to accommodate the Clinic's primarily low-income Hispanic immigrant population in fluoridated Northern Manhattan (28). Consenting caregivers who fulfilled inclusion criteria of being over the age of 18 years with nonspecial needs children 2 years (when full dentition is achieved) to 6 years of age were approached for participation.

All children were patients of record in the clinic and received routine comprehensive dental examinations as part of their initial or recall dental visit. Caregivers completed the MSB risk assessment tool, which provided data on the key independent variables of interest: MSB *comprehensive* risk score and MSB *diet* risk score.

Dental examinations were conducted by dental clinicians, which included an attending pediatric dentist, a pediatric dental resident, and a dental hygienist following standardized Clinic procedures using the "knee-to-knee" approach, whereby the child was held in the caregiver's lap, and the clinician visualized teeth with the use of a focused light and hand-held intraoral mirror. All clinicians were trained in identification of decalcifications and plaque scoring, using a modified Silness and Loe Plaque Index (29), through seminars and written materials as part of the pediatric dental training program at the clinic. Interexaminer reliability across the hygienist and the residents conducting examinations is evaluated daily with attending faculty at the clinic to ensure consistency in evaluation of clinical measures. All children received the standard of care at the clinic, which typically includes prophylaxis, topical fluoride application (commonly by varnish), and age-specific oral hygiene counseling. Clinical findings and services provided were entered into the facility's electronic

dental record. To assess levels of salivary mutans streptococci, saliva samples were collected immediately prior to the dental examination by depressing a sterile tongue depressor onto the dorsum of the tongue and transferring the saliva sample to the raised surface of mitis salivarius agar containing kanamycin and bacitracin (30). Agar plates were placed inside a plastic bag inflated with exhaled air to establish a partially anaerobic environment and incubated for 48 hours at 37°C in a countertop incubator (Complete Culture Control Incubator, Model 132000, Boekel Scientific, Troy, MI, USA). Agar plates were inspected by a single investigator (CLC) for numbers of characteristic colony-forming units (CFUs), and growth was classified as *low* (0 CFU), *moderate* (1-50 CFU), *high* (51-100 CFU), or *very high/too numerous to count* (>100 CFU) (30). Dental plaque on the mesiofacial, straight facial, and distofacial surfaces of four maxillary incisors was assessed using a modified Silness and Loe Plaque Index (29), and plaque levels were recorded, on the basis of the mean plaque score of the four teeth, as *none*, *mild*, *moderate*, or *heavy*. Enamel decalcifications were recorded using the World Health Organization's "Dentition Status and Treatment Needs" protocol (31) as *present* or *absent*. Evidence of frank cavitations, identified by presence of decayed/filled primary teeth and decayed/filled primary tooth surfaces, was recorded and used to identify children who did or did not meet diagnostic criteria for *ECC* or *S-ECC* (severe-ECC) (32).

Immediately following the dental examination, the interactive MSB risk assessment and behavioral intervention tool was administered to caregivers by one of the four DECC study investigators in a private conference room at the clinic. The four investigators were trained to follow a specific series of procedural steps outlined in a data collection guide created for the DECC study, which included training on the navigation and use of the MSB tool as well as training on appropriate anthropometric measurement techniques and the salivary mutans streptococci testing protocol.

All participants received a Metrocard (\$10 value) immediately upon completion of the 15- to 20-minute MSB assessment. The MSB risk assessment tool consists of a series of five assessment modules containing questions and brief educational units, one each on diet (e.g., What did your child eat yesterday?), feeding practices (e.g., How often do you prechew your child's food?), attitudes and beliefs (e.g., How confident are you in reducing your child's risk for tooth decay?), fluoride (e.g., What type of toothpaste does your child most routinely use?), and family history (e.g., Have you ever had an abscessed tooth?). Detailed information on diet and fluoride exposures are collected through unique modified 24-hour dietary recall and fluoride usage recall modules. These recall modules collect data on all oral exposures from diet-related behaviors (i.e., foods, beverages, and snacks consumed) as well fluoride-related behaviors (i.e., tooth brushing and use of fluoride mouth rinse) over the course of the preceding 24 hours. The educational units, related to ECC risk factors, are presented after responses to the MSB risk assessment questions are recorded, based on participant interest and learning needs. Additionally, MSB includes targeted goal setting and action planning modules that prompt caregivers to create behavioral goals based on current risk factors identified in the risk assessment modules. MSB facilitates behavior change counseling through these modules in which the caregiver works with the lay health worker to create a self-defined plan for taking action to reduce their child's ECC risk.

The MSB tool generates a *comprehensive* risk score, which is derived from all five risk assessment modules that capture information about caregiver knowledge, beliefs, attitudes, experience, and behaviors related to their child's oral health. Questions are assigned weights in a risk algorithm that is based on the caries risk literature, expert opinion of cariology and pediatric dentistry project advisors, and pilot data. Comprehensive and dietary risk scores are generated by MSB's backend software (23) as *low* (score: 1-3), *medium* (score: 4-6), and *high* risk (score: 7-10). The *diet* risk is included in the *comprehensive* risk score but was also evaluated independently.

A *diet* risk score is also generated by MSB, which is based on a standard 24-hour diet recall, but omits assessment of portion sizes and preparation methods. From a gallery of culturally appropriate food and beverage photographs, caregivers select what their child consumed during the prior day and identify the time of day that the food was consumed. Each food and beverage is assigned a risk weight of 0-4 based on the Palmer Classification of Cariogenicity and the expert opinion of cariology and nutrition advisors (23,25). MSB averages the cariogenicity of foods and beverages consumed together. A "risky" dietary caries exposure was considered to have occurred whenever the score for an eating occurrence exceeded "3" on the MSB "0-4" cariogenicity index. The total number of risky dietary caries exposures in the day determined an aggregate *diet* risk score of *low* (0 exposures), *moderate* (1-2), *high* (3-4), or *very high* (5 or more).

Risk scores and caries status were measured concurrently. Descriptive analyses detailed study population characteristics and all variables of interest. Ordinal logistic regression (OLR), using the Polytomous Universal Model procedure in spss software (Version 21.0, 2012, IBM Corp., Armonk, NY, USA), was used to test associations between risk scores and the four caries outcomes. OLR, a subset of general linear regression, allows examination of ordinal variables that are rank-ordered but not necessarily equidistant. Exploratory investigations of associations between demographic variables and physical indicators of caries revealed a potentially confounding effect of sex and age on physical indicators of caries, whereby these variables appear to have a statistically significant association with outcome variables of interest. Thus, both sex and age were held constant in all subsequent OLR analyses.

Results

A total of 108 caregiver/child dyads (95.6 percent of those approached for participation) were recruited to participate in the DECC study, all of whom completed the salivary mutans testing, comprehensive oral examination, and the MSB tool in its entirety. Demographic data (Table 1) identify the average age of participating children as just over 4 years (4.32 and 3.97 years for males and females, respectively); the majority was reported by caregivers to be Hispanic (88 percent), and sex was fairly evenly distributed, with a slight majority being female (56.5 percent). Participating caregivers were primarily mothers (88.9 percent), predominantly Spanish speaking (72.2 percent), and foreign born (75.9 percent). Data collected (from 92.6 percent of participants) regarding caregiver's self-reported highest level of educational achievement revealed that participants were fairly evenly distributed among

the three education categories. The majority of participants were posited to be low income, as indicated by participation in public assistance programs (Table 1).

Descriptive data on physical indicators of caries (Table 2) identified the majority of children in the DECC study as presenting with *moderate* levels of salivary mutans streptococci ($n = 65$; 60.2 percent), with the next most frequently observed levels falling within the *low* category ($n = 35$; 32.4 percent). The levels of salivary mutans streptococci levels with the fewest number of children were the *high* ($n = 5$; 4.6 percent) and *very high* ($n = 3$; 2.8 percent) levels. Evaluation of visible plaque quantity revealed that nearly half of the children were categorized with *mild* amounts of plaque ($n = 50$; 46.3 percent); only a small number of children were categorized as having *severe* amounts of visible plaque ($n = 5$; 4.6 percent), and the remainder of children were almost evenly distributed between the *moderate* ($n = 26$; 24.1 percent) and *none* ($n = 27$; 25 percent) categories. The data also reveal that nearly two-thirds of children presented with *no* evidence of decalcification ($n = 71$; 65.7 percent). Nearly half (49 percent) of the children did not meet the diagnostic criteria for ECC and were thus categorized within the *no ECC* category ($n = 53$). Conversely, 51 percent of children in the DECC study ($n = 55$) did present with evidence of ECC, and 41 (38 percent) met the diagnostic criteria for *S-ECC*.

Descriptive analysis of MSB *diet* risk score data reveals that the majority of DECC study participants received a *moderate* diet risk score (54.6 percent), with the next most common score being *low* (33.3 percent) (Table 3). Only two participants in the study (10.2 percent) received a *high* diet score. The *comprehensive* MSB risk score for DECC participants ranged from 1 to 8 (out of a possible score of 10), with a mean of 3.52 ($SD = 1.17$). Very few ($n = 1$) participants received scores in the lower and upper extremes (scores = 1, 6, 7, and 8) (Table 3).

Concurrent criterion validity of the dietary risk component of MSB was established by evaluating MSB *diet* risk scores and physical indicators of caries via OLR (Table 4). Holding participant sex and age constant, salivary mutans streptococci levels exhibited a statistically significant relationship with MSB *diet* score, indicating that higher levels of salivary mutans are associated with higher MSB diet scores ($P = 0.031$). For every one unit increase in MSB *diet* risk score, the odds of having *moderate*, *high*, or *very high* salivary mutans levels, as opposed to a *low* salivary mutans level, increase by a multiple of 1.26. MSB *diet* risk scores were not significantly associated with the other physical indicators of caries assessed in the DECC study, though there was a borderline significant relationship ($P = 0.061$) observed with visible plaque levels.

In evaluating the association between MSB *comprehensive* risk scores and physical indicators of ECC, OLR suggests that higher levels of salivary mutans and higher levels of visible plaque are both associated with higher *comprehensive* MSB risk Scores ($P = 0.035$ and $P = 0.043$, respectively) (Table 4). For every one-unit increase in *comprehensive* MSB risk score, the odds of exhibiting higher levels of salivary mutans (*moderate*, *high*, or *very high*) and visible plaque (*mild*, *moderate*, or *severe*) increase by a multiple of 1.49 and 1.41, respectively.

Discussion

Findings from the DECC study are promising, suggesting that MSB may be a valid tool for assessing a child's ECC risk. Recommendations from AAPD suggest that ECC risk assessment models incorporate evaluation of a multitude of ECC-related factors, including diet- and fluoride-related behaviors, individual susceptibility, socioeconomic status, and cultural influences (19). In contrast to previously developed ECC risk tools, MSB meets these recommendations by incorporating assessment of several known risk factors from varying levels of influence. The results of this concurrent criterion validation analysis confirm that MSB accurately identified children exhibiting early stage indicators of the ECC disease process (i.e., high levels of salivary mutans streptococci and visible dental plaque). As early identification of risk is an important component of effective disease prevention and management interventions, this finding is encouraging. By identifying children at the earliest stages of the caries disease process, MSB holds the potential to fill the current void in effective ECC risk assessment tools. ECC is a largely preventable disease, whose progression can be halted through sufficient targeted intervention. Thus, making the application of effective risk assessment with targeted early intervention essential to mitigating the effects of this impactful disease. Future application of MSB in a larger prospective study may provide a more clear indication of its ability to predict, and ultimately prevent, future caries in children at risk.

A major strength of the DECC study is that it was conducted within a busy dental clinic, serving a segment of the population that has historically suffered disproportionate rates of ECC, in both ECC prevalence and severity. Since, MSB content was specifically tailored to the target population and the DECC study employed the use of bilingual investigators, language barriers were minimized, allowing researchers to communicate well with participants in their preferred language, thereby building rapport and trust while also facilitating administration of study procedures and data collection.

Though compelling, the findings of the DECC study must be considered within the context of the study's limitations. The DECC study had a limited sample size with 108 caregiver/child dyads. Several of the associations investigated were borderline significant, and may have been statistically significant if a larger sample size had been included. Findings are also limited to the population under investigation, for which MSB was customized. However, it should be noted that as a technology-based tool, MSB allows for future customization and cultural tailoring with relative ease.

Because the DECC study only included children presenting for routine dental examinations, and excluded those visiting the clinic for urgent care or restorative procedures, there was a limited range of children with the highest severity of physical caries risk indicators. Children visiting the clinic for urgent care, surgical, or restorative procedures were not included because caregivers would likely be anxious about their care, making participation difficult, and because clinicians do not routinely collect data on all four physical indicators of interest in the DECC study during such visits. Future studies exploring the effectiveness of MSB may want to ensure inclusion of children presenting with a broader range of oral disease to assess a larger percentage of children exhibiting the highest levels of caries risk.

Conclusions

Given the current lack of risk assessment tools that can accurately identify children at high risk of ECC, these findings are encouraging and have been used to inform the design of several larger and longer-term studies to determine the ultimate utility of MSB. As a comprehensive, technology-assisted risk assessment tool, MSB holds promise to fill the current gap in utilization of risk assessment tools in pediatric dentistry. The MSB software ensures fidelity to evidence-based recommendations, as the targeted educational messages delivered during administration are grounded in social, behavioral, and dental science, thus enabling administration by lay health workers with minimal oral health training and providing an opportunity for low-cost delivery of ECC risk assessment and disease management. MSB may thus provide clinicians and other health workers with an easy-to-administer and effective means to assess risk, inform risk-based care, and provide children and their families with targeted instruction to promote ECC prevention and facilitate disease management through counseling to encouraging positive behavior change.

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Table 1

Demographic Data

Variable	<i>n</i>	%
Total sample	108	100
Child's sex		
Male	47	43.5
Female	61	56.5
Child's age (<i>M</i> = 4.12 years)		
2	21	1.4
3	24	22.2
4	31	28.7
5	29	26.9
6	3	2.8
Child's race/ethnicity		
African American	12	11.1
Caucasian	1	0.9
Hispanic	95	88.0
Caregiver relationship		
Mother	96	88.9
Father	11	10.2
Grandparent	1	0.9
Caregiver immigration status		
US born	26	24.1
Foreign born	82	75.9
Caregiver language preference		
Spanish	78	72.2
English	26	24.1
English/Spanish	4	3.7
Caregiver educational achievement		
No data	8	7.4
Did not complete high school	34	31.5
Completed high school	35	32.4
Completed more than high school	31	28.7
Food stamp recipient	76	70.4
WIC participant	67	62.0
Insurance coverage		
Medicaid <i>only</i>	4	3.7
Medicaid <i>Plus</i> supplementary coverage	103	95.4

Table 2

Physical Indicators of Caries

Indicator	<i>n</i>	%
Oral mutans		
Low	35	32.4
Moderate	65	60.2
High	5	4.6
Very high	3	2.8
Visible plaque		
None	27	25
Mild	50	46.3
Moderate	26	24.1
Severe	5	4.6
Decalcifications		
No	71	65.7
Yes	37	34.3
ECC classification		
No ECC	53	49
ECC	14	13
S-ECC	41	38

Table 3**MSB Diet and Comprehensive Risk Scores**

MSB score	<i>n</i>	%
Diet risk		
Low	36	33.3
Moderate	59	54.6
High	11	10.2
Very high	2	1.9
Comprehensive risk		
Low		
1	1	0.9
2	18	16.7
3	42	38.9
Medium		
4	24	22.2
5	20	18.5
6	1	0.9
High		
7	1	0.9
8	1	0.9

Table 4

Diet and Comprehensive Risk by Physical Indicators of Caries OLR

Physical indicator	Logit	OR	P
Diet risk			
Oral mutans	0.228	1.26	0.031
Visible plaque	0.175	1.19	0.061
Decalcification	−0.076	0.93	0.532
ECC classification	0.034	1.03	0.725
Comprehensive risk			
Oral mutans	0.397	1.49	0.035
Visible plaque	0.345	1.41	0.043
Decalcification	0.142	1.15	0.489
ECC classification	−0.063	0.94	0.726

Participant age and sex are held constant in this OLR analysis. OR, odds ratio.