Disease Management of Early Childhood Caries: Results of a Pilot Quality Improvement Project

Man Wai Ng, DDS, MPH
Gay Torresyap, RDH, MS
Alex White, DDS, DrPH
Patrice Melvin, MPH
Dionne Graham, PhD
Daniel Kane, DMD
Richard Scoville, PhD
Henry Ohiomoba, BDS, MPH

Abstract: Objectives. The purpose is to report findings of a quality improvement (QI) project implemented at two hospital-based dental clinics that care for children with early childhood caries (ECC). Methods. We tested a disease management (DM) approach in children younger than age 60 months with ECC. Results. After 30 months, for the 403 and 234 DM patients at Children's Hospital Boston (CHB) and Saint Joseph Hospital (SJH) who returned for at least two visits, rates of new cavitation, pain, and referrals to the OR were 26.1, 13.4 and 10.9% for CHB and 41.0, 7.3 and 14.9% for SJH. Rates of new cavitation, pain, and referrals to the OR for historical controls were 75.2, 21.7, and 20.9% for CHB and 71.3, 31.3, and 25.0% for SJH. Conclusions. A risk-based DM approach utilizing QI strategies to address ECC can be implemented into practice and has the potential to improve care and health outcomes.

Key words: Early childhood caries, disease management, quality improvement, oral health, children, underserved.

Early childhood caries (ECC) continues to be the most common chronic condition among children in the United States, with prevalence in 2–5 year-olds having increased 15% in recent years to 28%.\textsuperscript{1} Nearly half of all children experience cavities before entering kindergarten,\textsuperscript{2} with minority and low-income children disproportionately affected.\textsuperscript{3}

Dental caries, a multi-factorial disease caused by oral bacteria and mediated by dietary sugars and carbohydrates, is largely preventable.\textsuperscript{4} It is a dynamic disease that can progress and/or regress, depending upon a multitude of variables that determine the balance of demineralization and remineralization.\textsuperscript{5,6} As with other chronic diseases, children's oral health is influenced by various social and behavioral factors,\textsuperscript{7} such as diet, oral hygiene practices, and fluoride exposure.\textsuperscript{8,9} Families play an important role in children's oral health\textsuperscript{7} since their beliefs and sense of self-efficacy help determine to what extent they engage in oral health promoting behaviors.\textsuperscript{10,11}

Until recently, standards of care for ECC called for restorative and surgical treatment, along with general recommendations to change dietary and oral hygiene practices.\textsuperscript{12,13} However, surgical treatment of caries alone does not address the disease process.\textsuperscript{6} Featherstone's caries balance states that the balance of pathologic factors can be altered in favor of protective factors to halt or slow down the caries process. Without changes to alter that balance, the caries process continues with new and recurrent caries resulting.\textsuperscript{5}

Although contemporary approaches to caries management (modeled after the chronic care model) have been published in the dental literature,\textsuperscript{4,6,14} risk-based disease management (DM) of caries remains to be widely implemented in clinical practice.

**Hospital-based pediatric oral health care.** Like many hospital-based dental practices that care for disproportionate numbers of children with ECC and serve as referral centers for uncooperative young children with ECC who cannot be treated in the dental office, Children's Hospital Boston (CHB) and Saint Joseph Hospital (SJH) were managing ECC \textit{via} predominantly restorative/surgical approaches. Both clinics had waiting times of four to six months for dental care in the OR. During the wait for the OR, disease typically progressed and symptoms commonly arose or worsened. Children returning with acute symptoms were moved to the head of the list, leaving others at greater risk for developing pain or infection.

In addition, the costs of general anesthesia are high\textsuperscript{15–18} and relapse rates (restorative treatment failures) of 37–79% have been reported.\textsuperscript{19–22} Furthermore, general anesthesia carries an inherent risk to the health and safety of the patient.

**Paradigm shift toward chronic disease management (DM) of ECC.** In 2008, with a goal to improve patient care and clinical outcomes, CHB and SJH implemented a demonstration project to address ECC in children younger than 60 months of age. A DM clinical protocol was developed that included a caries risk assessment tool (CAT) (Figure 1) adapted from the American Academy of Pediatric Dentistry\textsuperscript{23} and Caries Management by Risk Assessment (CAMBRA).\textsuperscript{4} Scripts were developed for use by providers to explain the caries process and its causative factors. Written educational materials, including a self-management goals handout (Figure 2) adopted from CAMBRA,\textsuperscript{4} were to be given to parents, to aid in encouraging them to participate in the management of their child's caries.

**DM clinical protocol.** The evidence-based clinical protocol for children with ECC (Figure 3) included both in-office and at-home components.
Figure 1. Caries Risk Assessment Tool (CAT) used at CHB and SJH.

ECC = Early Childhood Caries
CHB = Children’s Hospital Boston
SJH = Saint Joseph Hospital

In-office caries management consisted of applying fluoride varnish and re-assessing caries risk regularly based on the assumption that children who initially presented as high caries risk may decrease their risk over time. The periodicity for the DM visits was determined by the most recent caries risk assessed, in conjunction with restorative care as needed and desired by the parent and provider. Patients deemed to be at high
Parents were given the full options for restorative treatment, which might require pharmacologic management (nitrous oxide, sedation or general anesthesia) as adjunct. If the destruction of tooth structure by the caries process was minimal, arrest of the decay might be possible with remineralization of tooth structure. The restorative treatment...

Figure 2. Self-management goals handout for parents.

caries risk returned in 1–2 months, moderate-risk patients in 3–4 months; and low-risk patients in 6–12 months.
was deferred in patients if the disease was stabilized. When decay had progressed into dentin and caries arrest was not achieved, interim therapeutic restoration (ITR) was offered as an alternative treatment in young children with early cavitated lesions. Parents were informed that this approach is caries control rather than permanent restoration.

For the at-home protocol, pathologic factors identified from interviewing the parent were presented as a menu of self-management goals (Figure 2) for caregivers to select from and work on before the next visit. In our protocol, 0.4% stannous fluoride

Figure 3. Risk-based disease management clinical protocol.
Disease management of early childhood caries (1000 ppm fluoride) was recommended to be applied judiciously two or three times per day by the parent after tooth brushing. Parents may elect to use over-the-counter 1000 ppm fluoride toothpaste instead. A few parents who had concerns about fluoride were apprised of xylitol, casein phosphopeptide and calcium phosphate products. Since this project was focused on process improvement and not a randomized clinical trial, there was flexibility in implementing the clinical protocol.

**Practice redesign using Quality Improvement methods.** Quality improvement (QI) has been defined by Batalden as the combined and unceasing efforts of everyone to make changes that will lead to better patient outcomes (health), better system performance (care), and better professional development (learning). It is also defined as systematic, data-guided activities designed to bring about immediate improvements in

![Driver diagram for the ECC demonstration project.](image)

ECG = Early Childhood Caries
CHCs = Community Health Centers
PCPs = Primary Care Providers
health care delivery in particular settings. The Institute for Healthcare Improvement (IHI) Model for Improvement was used to guide making changes in our care delivery systems in order to use a DM approach for ECC. We developed a driver diagram outlining three main outcomes of interests: 1) new cavitation (cavities); 2) pain related to untreated caries; and 3) referral to the OR, along with primary and secondary drivers affecting those outcomes.

In this project, dental care providers and parents who were accustomed to surgical treatment of ECC, had to be reprogrammed to accept a modern caries management approach that emphasizes prevention, individualized risk assessment and management of disease. Our scheduling systems, which had been set up to accommodate patients to receive a preventive visit every six months as allowed by insurance reimbursement, now had to be re-engineered to include more frequent return preventive visits for patients with an increased caries risk.

Additionally, QI activities were adopted based on the IHI Chronic Care Model which assumes that patients have a central role in determining the care of their chronic medical conditions, such as diabetes and asthma. Chronic disease management differs from a traditional approach of telling patients what to do and instead fosters a sense of responsibility on the part of the patient for their own health. It assumes a collaborative relationship between care provider and patient and is dependent upon an active and informed patient. The patient/parent is informed of the disease process and is assisted in selecting self-management goals to reduce the risk factors for disease. Treatment decisions are based on explicit, proven guidelines supported by evidence; the care delivery system is set up to ensure patients receive the care they need.

Before implementing this project, attendings and residents at CHB and SJH received training on DM and QI methods and participated frequently in meetings to address questions about the clinical protocol and care management of patients, review project progress, and to plan PDSAs (plan-do-study-act). Training was offered to new care providers and retraining to others annually.

Methods

Objective. In this report, we describe the findings of a QI demonstration project implemented at CHB and SJH. The project aimed to test the feasibility of a chronic DM approach in children younger than age 60 months with ECC and evaluate patient care outcomes: 1) new cavitation; 2) pain related to untreated caries; and 3) referral to the OR.

Design. Although the project was implemented as a QI project, institutional review board (IRB) approval was sought and obtained at both CHB and SJH. Parents of children younger than 60 months of age with active caries or a history of ECC were invited to participate. By giving written informed consent, parents agreed to follow the clinical protocol and return for DM visits based on the caries risk determined during each visit. Participation was voluntary and parents could opt out at any time.

Children’s Hospital Boston and SJH commenced with subject enrollment on March 1, 2008 and April 1, 2008 respectively. The project’s official end date was December 30, 2009, with the last subjects enrolled in September 2009. Children’s Hospital Boston elected to continue subject enrollment and data collection until September 30, 2010. SJH
elected to discontinue with subject enrollment and follow-up of the enrolled subjects after the project officially ended.

**Patient registry.** Subject data were collected by the dental providers seeing the patients onto a paper CAT, which included questions regarding new incidence of demineralization, cavitation, pain, referral to the OR and caries risk determined for the patient at the particular visit. Completed paper CATs were collected weekly and all data were entered into an Access 2003 database (Microsoft Inc., Redmond, Wash). From this patient registry, patients were also monitored for returned and failed appointments and were contacted by mail or telephone to schedule their return visits. De-identified data of the ECC patients enrolled at SJH were sent monthly by secure electronic transfer to CHB by SJH as an Excel spreadsheet. All the data received were then entered into the Access database housed at CHB.

After 13 months, CHB converted from using paper patient dental records to electronic records. The CAT became incorporated into the electronic patient record. The Access database registry was updated monthly with information from paper or electronic versions of the CAT’s.

**Historical control data.** Although, this study was designed as a QI project that aimed to identify positive trends in process and outcome measures that would signify improvements in patient care delivery and/or patient outcomes, a trends analysis would not necessarily infer causality. Therefore, there was a need to compare the ECC project outcomes data to baseline data derived from historical controls (i.e., patients treated at CHB and SJH prior to the start of the DM protocol).

At CHB and SJH, historical control data were obtained by performing a retrospective chart review in April 2009 and October 2009 respectively, of patients younger than 60 months of age who had a recall exam from January 2006 to December 2006. A computer generated randomized scheme identified potential patients, whose billing records were reviewed to determine whether they had restorative treatment prior to their recall visit in 2006. The patients who had restorative treatment charged out were deemed to have a history of caries. These patient records were selected for further review. The following information was documented by visit date: 1) type of visit (preventive, restorative, sedation, OR, missed or canceled), 2) new cavitation identified, 3) pain identified and 4) referral to OR. The first visit was determined for each patient as that which caries was initially charted or documented in the patient’s clinical notes. Pain and OR referral at first visit, including pain unrelated to untreated decay at any visit were excluded, as was done in the ECC study group. From this information, the percentage of patients with new cavitation, pain identified and referral to OR, along with time until new cavitation were determined.

At CHB, 129 patients met the criteria and their data from visits between April 23, 2003 and March 5, 2009 were entered onto paper data collection sheets, followed by entry into an Access database. At SJH, the outcome data was collected onto paper collection forms in a de-identified manner. The forms were sent to CHB, where the data were entered onto an Access database. Eighty patients met the criteria and their data from visits at SJH between October 21, 2004 and October 19, 2009 were entered onto paper data collection sheets, followed by entry into an Excel spreadsheet.

**Data management and statistical analysis.** All data were exported to SAS software
version 9.2 (SAS Institute Inc. 2010. SAS® 9.2) for analysis. Descriptive analyses of patient characteristics among the CHB and SJH groups were summarized using means and standard deviations for continuous variables and proportions for categorical variables. Differences in patient characteristics across the historical control and ECC intervention groups were analyzed using Pearson's chi-squared for categorical variables and one way analysis of variance (ANOVA) for continuous variables. We used Kaplan-Meir curves and Cox Proportional Hazards model to analyze time to event series between the groups. A p value $<.05$ was considered statistically significant.

At CHB, a two sample survival power analysis was used to determine the minimum number of historical controls necessary to detect a 10 percentage point difference in the occurrence of new cavitation between historical control and intervention groups (power = 0.8). We determined that a minimum of 100 controls would give our study the power necessary to detect this difference. Historical controls included children who were seen at CHB from April 2003 through December 2007 and were under 60 months of age at the first visit (with an age cut-off of 80 months as determined by ECC protocol). Because our historical control group had a longer follow up period, we limited the follow up time for patients in this group to 933 days (comparable to longest follow up in the ECC group).

Results

As of September 2010 (30 months of data at CHB and 20 months at SJH), 758 patients had been enrolled at both sites. 475 patients were enrolled at CHB and 283 patients were enrolled at SJH. Eighty-five percent (403) of enrolled subjects at CHB and 83% (234) at SJH returned for at least two visits. One-hundred and twenty-nine and 80 patients constituted the historical control groups at CHB and SJH.

Table 1 presents a comparison between the ECC and historical control groups at CHB in terms of patient demographic information, mean number of visits, and length of follow-up. There were no significant differences in the mean age of the two groups, the percentage of children younger than age four at the first visit and the percentage of children who were publicly insured (i.e., Medicaid-coverage). The mean follow-up time in terms of days was 49% longer in the control group than in the ECC group (p <.001), while the ECC patients had almost two times as many visits per year as control patients (p <.001). Nearly 70% (68.6%) of the ECC group and 82.1% of the control group were from homes where English was the primary language (p <.005).

Table 2 presents a comparison between the ECC and historical control groups at SJH in terms of patient demographic information, mean number of visits, and mean length of follow-up. No information was available for primary language spoken or insurance coverage for the historical control group. There was no difference in age at the first visit of the ECC children compared to the control group (p <.2). There were significant differences in the mean number of visits per year and mean length of follow-up time. The mean follow-up time in terms of days was three times longer (p <.001) while the mean number of visits per year was 44% greater (p <.001) than for the ECC group.

Table 3 shows the percentage of enrolled subjects at CHB and SJH with at least two visits presenting with the three main outcomes of interest: new cavitation, pain, and
referral to the OR after the first visit compared to that of historical control patients. Of those with at least two visits, rates of new cavitation, pain, and referrals to the OR were 26.1, 13.4 and 10.9% for CHB and 41.0, 7.3 and 14.9% for SJH. In contrast, rates of new cavity, pain and referrals to the OR for the historical control patients were 75.2, 21.7, and 20.9% for CHB and 71.3, 31.3, and 25.0% for SJH.

**Pertaining to CHB only.** Of the 403 CHB patients with at least two visits, the mean number of visits was 5.3, the mean follow-up time in terms of days was 377.4 days, and the mean visits/year was 9.2. 39.8% (160/403) of these patients presented with new remineralization of at least one tooth surface.

Of the 403 patients with at least two visits, 334 had at least two documented caries risk. As of their last visit with documented caries risk, the percentage of patients whose caries risk had improved, worsened or not changed were, respectively: 40.4% (135/334), 4.2% (14/334) and 55.3% (185/334).

Figure 5 shows the overall risk level by visit number. 87.9% (336/403) of the patients

---

**Table 1.**

**CHARACTERISTICS OF ECC PATIENTS AND HISTORICAL CONTROLS AT CHB**

<table>
<thead>
<tr>
<th></th>
<th>Total Patients</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N)</td>
<td></td>
</tr>
<tr>
<td>English as Primary Language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECC</td>
<td>383 Event (N)</td>
<td>68.4</td>
</tr>
<tr>
<td>Historical Control</td>
<td>117 Event (N)</td>
<td>82.9</td>
</tr>
<tr>
<td>Public Insurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECC</td>
<td>392 Event (N)</td>
<td>78.1</td>
</tr>
<tr>
<td>Historical Control</td>
<td>121 Event (N)</td>
<td>71.9</td>
</tr>
<tr>
<td>Age (years) at First Visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECC</td>
<td>398 Mean</td>
<td>1.0</td>
</tr>
<tr>
<td>Historical Control</td>
<td>122 Mean</td>
<td>0.9</td>
</tr>
<tr>
<td>Age under 4 years at First Visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECC</td>
<td>398 Event (N)</td>
<td>79.4</td>
</tr>
<tr>
<td>Historical Control</td>
<td>122 Event (N)</td>
<td>72.9</td>
</tr>
<tr>
<td>Mean Visits per Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECC</td>
<td>403 Event (N)</td>
<td>10</td>
</tr>
<tr>
<td>Historical Control</td>
<td>124 Event (N)</td>
<td>2</td>
</tr>
<tr>
<td>Follow-up Time (days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECC</td>
<td>403 Mean</td>
<td>262</td>
</tr>
<tr>
<td>Historical Control</td>
<td>129 Mean</td>
<td>274</td>
</tr>
</tbody>
</table>

ECC = Early Childhood Caries  
CHB = Children’s Hospital Boston  
NS = Not Significant; no statistically significant difference between the two groups  
SD = Standard Deviation
with at least two visits were evaluated as high caries risk at their first visit. With increasing number of visits by patients, the proportion of high risk patients declined, while the proportion of medium and low risk patients increased. The critical visit appeared to be the third visit, during which high risk and moderate risk lines intersected. A survival analysis performed of the time to new cavitation between the two groups found that ECC patients had 62.2% lower risk of new cavitation than control patients at any given point in time (Hazard Ratio: 0.388; p < .001). (Figure 6)

**Discussion**

This may be the first published study which demonstrates that risk-based DM of ECC can be systematically implemented into clinical practice. Results from our pilot study show that significantly fewer ECC patients at CHB and SJH experienced new cavitation, pain, and OR referrals as compared with historical control groups.

The differences in improved rates of outcomes for the ECC patients compared with
Table 3.

COMPARISON OF RATES OF NEW CAVITATION, PAIN AND REFERRAL TO OR BETWEEN ECC PATIENTS AND HISTORICAL CONTROLS

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>CHB</th>
<th></th>
<th>SJH</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECC (N=403) %</td>
<td>Historical Control (N=129) %</td>
<td>ECC (N=234) %</td>
<td>Historical Control (N=80) %</td>
</tr>
<tr>
<td>New cavitation</td>
<td>26.1</td>
<td>75.2</td>
<td>41.0</td>
<td>71.3</td>
</tr>
<tr>
<td>Pain</td>
<td>13.4</td>
<td>21.7</td>
<td>7.3</td>
<td>31.3</td>
</tr>
<tr>
<td>Referral to OR</td>
<td>10.9</td>
<td>20.9</td>
<td>14.9</td>
<td>25.0</td>
</tr>
</tbody>
</table>

ECC = Early Childhood Caries
CHB = Children's Hospital Boston
SJH = Saint Joseph Hospital

Figure 5. Overall risk by visit number: the proportion of high risk patients decline with consecutive visits at CHB.

CHB = Children's Hospital Boston
aVisits during which there was no documented evaluation of caries risk were excluded
bOnly patients with at least two visits where included
cA maximum of 8 visits per patient was used because very few patients had 9–14 visits.
The greater improvement rates at CHB may be due to the cultural and socioeconomic variations between the families of the practices. Compared with SJH, fewer parents of patients at CHB self-identified with a primary language other than English or were Medicaid insured. In contrast, while actual data were not available for SJH’s historical control patients, 99.1% of SJH’s ECC patients were Medicaid insured and 38.8% were from homes where the primary language was English. Most of SJH’s clinic patients were immigrants from Latin American countries. Studies have found caries prevalent among children of low socioeconomic and Latino background along with a lack of oral health knowledge by their parents, including about caries prevention.29–31

Almost all patients enrolled into the project were high caries-risk to begin with. A small group of patients had been recommended the DM protocol and complying with it, and thus were medium risk when enrolled in the project. High-risk and medium-risk appear to intersect at the third visit, suggesting that patients who returned more frequently for preventive care may be more willing to change home care practices which resulted in perceived improved caries risk by the provider. Typically, provider caution reigned until evidence of improved risk was sustained over time, to at least the third follow-up DM visit.

Clinical implications. Given the high-caries risk of the patients at CHB and SJH, where language and cultural influences were potentially significant barriers to parents’ self-efficacy, health promotion and seeking behaviors, the fact that a DM protocol for
Disease management of early childhood caries

ECC that was predicated on frequent return visits could be implemented, suggests a strong potential for DM approaches to be feasible in other practice settings.

Risk-based DM of ECC requires parental engagement and willingness to alter diet, oral hygiene and possibly fluoride exposure, and to return for more frequent follow-up visits. 15% at CHB and 17% at SJH of ECC enrolled patients did not return for a second visit. The project attempted to reach out to some families—often unsuccessfully. We speculate that these parents may have been dissatisfied with the DM approach or were unable to fulfill the project requirements or relocated.

At CHB, 25 one-hour long structured telephone interviews with randomly selected ECC parents were conducted from June to September 2009. Some findings from these structured interviews have already been published. Unpublished findings include the belief by most parents that ECC DM approach was helpful for their children. Almost all parents appreciated being given reasons why their children may have developed ECC. Some parents believed the DM approach to be less judgmental and felt less blamed for their child's condition. Some liked the collaborative/partnership relationship with providers, believing that they were given a voice in the dental care of their children. Several specifically mentioned stannous fluoride as the easiest self-management goal to comply with at home.

After the ECC demonstration project officially ended in December 2010, the DM protocol became standard of care for all patients and providers at CHB. The dental providers determined that it was not possible to predict which families could comply with self-management goals. They concluded that all patients and parents would benefit from the DM of caries and supported the practice moving completely to this approach.

**Study limitations.** This project had some important limitations. In early 2008, since neither CHB nor SJH could report to our IRBs that risk-based DM of caries was standard of care, written informed consent for voluntary participation was recommended. In doing so, selection bias was likely unavoidable.

Dental providers at both sites received training on the DM protocol specifically to chart caries using a proprietary system (modified from the International Caries Detection and Assessment System), but they were not calibrated to identify and chart new incidences of cavitation. Additionally, since the historical control patients were followed significantly longer than the ECC patients, the controls may be expected to have greater opportunities for caries to develop over time. The survival analysis performed at CHB was intended to adjust for differences in length of follow-up and found that at any given point in time, there was a 38% greater risk of controls developing new cavitation compared to ECC patients. However, since ECC patients had almost twice as many visits at CHB and almost 1.5 times as many visits at SJH compared with historical control patients per year, during which they would be expected to be examined for new cavitation and evidence of caries inactivity/remineralization by tooth surface, they may have experienced increased opportunities for new cavitation to be identified.

Other issues include the limits of chart audits. For example, CATs were not always completed or incompletely documented by providers during visits with ECC patients due to time constraints and other reasons. Patients who presented for an emergency or for treatment in the operating room did not have a CAT completed.

**QI's potential to transform oral health care delivery.** Applying the principles of
QI, this project was able to make changes within our practices’ oral health care delivery systems to support risk-based DM of ECC. However, despite the scientific community in recent years advocating the use of bio-behavioral approaches to prevent and control the caries process, clinical dental practice today remains primarily focused on surgical care and the treatment of the consequences of the disease. In general, dental providers have not received training on DM of caries nor have they been accustomed to provide effective counseling on DM. Even if providers were interested in incorporating DM into patient care, our delivery systems of dental care do not easily support this approach. In addition, patients and families, along with the public, lack basic knowledge of the causes of dental caries and the oral health literacy to easily accept risk based recommendations on disease prevention and management of caries.

Quality improvement involves making changes that systematically incorporate evidence-based knowledge and functions at the system level by which care delivery takes place. In this project, many small tests of change were performed and those served as learning opportunities on how risk assessment may be better performed, how self-management goals may be conveyed, and how patients may be more effectively scheduled for appointments. Quality improvement is intended to support redesign of care processes, based on a system of learning, incremental change, and incorporation of best practices from evaluating performance and outcome measures.

In recent years, hospitals and medical health care systems have increasingly been using QI methods to enhance patient safety, improve quality of care, and management of chronic disease and preventive care. Although QI activities are not yet familiar to dentistry, they offer the potential to transform oral health care delivery in order to provide better care, improve outcomes, and reduce costs of treatment of caries.

Policy implications. For a successful paradigm shift to risk-based disease prevention and management to occur, reimbursement is needed for caries risk assessment, diagnosis, non-surgical management of caries, more frequent risk-based DM visits for some appropriate patients, education and counseling. These activities are not presently reimbursable by insurance in our current fee for service system. Providers cannot be expected to adopt DM approaches while they are incentivized only for surgical care. At the same time, dental diagnostic codes and new systems of documenting disease activity are needed to support risk-based DM of caries.

The public and providers will need to be educated toward a frame shift focused on maintaining oral health. As we have found from the limited interviews conducted with ECC parents, families may be receptive to approaches that conceptually make sense and are of value, and to engage in collaborative family-centered care with their providers.

Future work. Thirty months of promising results are reported from a demonstration project on DM of ECC. We intend to follow the progress of the 403 CHB ECC patients to report on longer-term results. Despite having demonstrated improvements in clinical care practices and health outcomes in the application of an ECC DM protocol, there is a need to consider financial sustainability of the approach and to study its cost effectiveness.

Since this demonstration project was implemented at two hospital-based dental practices that care for large numbers of high-caries risk children, these results may not be generalizable. The risk-based DM approach to ECC will need further testing, in other
diverse settings with other providers, to determine its feasibility, and its effectiveness to improve quality of care, health outcomes and cost.

**Conclusion.** A risk-based DM approach utilizing quality improvement strategies to address ECC can be implemented into dental practice and has the potential to deliver better care and improve clinical outcomes.

**Acknowledgments**

The ECC demonstration project was supported by the DentaQuest Institute. Additional support was provided by the Program for Patient Safety and Quality at Children's Hospital Boston.

**Notes**