Published in final edited form as:
*Acad Pediatr*. 2009 ; 9(6): 396–403. doi:10.1016/j.acap.2009.08.006.

# Update on Early Childhood Caries since the Surgeon General's Report

**Norman Tinanoff, DDS, MS**** and
Department of Health Promotion and Policy, University of Maryland Dental School, Baltimore Maryland, P 410 706 7970, F 410 706 4031

**Susan Reisine, PhD**
Department of Oral Health and Diagnostic Sciences, Division of Behavioral Sciences and Community Health, University of Connecticut School of Dental Medicine, Farmington, CT 06030, P: 860 679 3823, F:860 679 3214

Norman Tinanoff: Ntinanoff@umaryland.edu; Susan Reisine: reisine@nso1.uchc.edu

## Abstract

The 2000 Surgeon General's Report on Oral Health (SGROH) included a limited discussion of the condition known as Early Childhood Caries (ECC). Because of its high prevalence, its impact on young children's quality of life and potential for increasing their risk of caries in the permanent dentition, ECC is arguably one of the most serious and costly health conditions among young children.

A necessary first step in preventing dental caries in preschool children is understanding and evaluating the child's caries risk factors. Previous caries experience and white spot lesions should automatically classify a preschool child as high risk for caries. Microbial factors, such as presence of visible plaque and tests that identify a child as having high levels of mutans streptococci also predict caries in young children. Frequency of sugar consumption, enamel developmental defects, social factors such as socioeconomic status, psychosocial factors, and being an ethnic minority also have shown to be relevant in determining caries risk.

Based on this knowledge of specific risk factors for an individual, different preventive strategies as well as different intensities of preventive therapies can be employed. Caries preventive strategies in preschool children include fluoride therapy, such as supervised tooth brushing with fluoridated dentifrice, systemic fluoride supplement to children living in a non-fluoridated area that are at risk for caries, and professional topical fluoride with fluoride varnish. There is emerging evidence that intensive patient counseling or motivational interviews with parents to change specific behaviors may reduce caries prevalence in their children. Findings regarding antimicrobial interventions, efforts to modify diets, and traditional dental health education are less consistent.

### Keywords

early childhood caries

** corresponding author.

**Potential conflicts**: None

The purpose of this manuscript is to provide an update of Early Childhood Caries (ECC) to health care providers in the areas of epidemiology, societal impact, risk factors, and interventions to reduce the disease. Of importance to clinicians are two summary tables, one that will help identify and categorize caries risk factors for preschool children, and a second that identifies caries management approaches to reduce early childhood caries by risk categories.

## Epidemiology

Although ECC was known to be a significant problem in preschool populations at the time of the Surgeon General's Report on Oral Health (SGROH) in 2000, comprehensive understanding of its epidemiology has been limited due to the lack of a case definition, complexity in accessing this age group for data collection, and the difficulty in examining these young children. The first reports of caries prevalence in preschool populations in the United States were derived from convenience samples of Head Start and WIC populations that may be at higher caries risk than the general population.[1]

A better understanding of the epidemiology of caries in preschool children and prevalence trends can be derived from reports of the National Health and Nutrition Examination Survey (NHANES III) conducted between 1988-1994,[2] and 1999-2004 data collected by the ongoing National Health and Nutrition Examination Survey.[3] National studies are more reliable than other surveys because they include large representative samples with careful standardization of examiners. Furthermore, because the surveys include data on socioeconomic factors, insights can be derived regarding the prevalence of dental caries and its treatment in U.S. preschool children at various income levels. Two measures are caries are useful. Prevalence refers to the presence of any carious lesions severe enough to cause cavities or be restored with fillings. The extent or intensity of caries attack in an individual is measured by the number of decayed or filled primary teeth (dft) or surfaces (dfs).

The 1988-1994 NHANES data showed a high number of dft in U.S. preschool children. Poor and near poor two-year olds had an average of half a dft per child, and the number of lesions was greater in older age groups, with the poor and near poor five-year-old children having 2.7 dft. In contrast, the mean dft for non-poor five-year-olds was less than 1. Separate analysis of data from only those children with caries demonstrates the severity of disease among these children. For instance, irrespective of economic status, two-year-old children with caries had more than 3 lesions per child. Differences in dft between economic levels was also less evident in three- and five-year-olds with caries. Thus, while fewer non-poor children had decayed teeth, those with decay, on average, experienced disease severity similar to that of poor and near poor children[4].

Analysis of 1988-1994 NHANES data indicated that more than half of the poor and near poor five-year-olds had caries, and that the disease was essentially untreated among these children, as shown by the percentage of untreated decay[4]. Data from the more recent study indicate that the prevalence of dental caries of children 2-5 years old increased from 24% in 1988-1994 to 28% in 1999-2004.[3] Overall, considering all 2-5 years olds, the 1999-2004 survey indicates that 72% of decayed or filled tooth surfaces remain untreated.[3]

Therefore, the data clearly indicate that: 1. caries is highly prevalent in poor and near poor U.S. preschool children; 2. in contrast to declining prevalence of dental caries among children in older age groups, the prevalence of dental caries in U.S. children under the age of five has increased; 3. those children with caries experience, regardless of income status, have high numbers of teeth affected; and 4. dental caries in U.S. preschool children is largely untreated.

## Child, Family and Societal Impact of ECC

The SGROH devoted a chapter, Effects on Well-Being and Quality of Life, to individual, family and societal impacts of oral health and oral diseases. Oral health related quality of life was defined as a multidimensional concept that included physiological function, symptoms, social functional, psychological well-being and economic costs. Children 5 to 7 years of age in the United States have been estimated to lose more than 7 million school hours annually because of dental problems and/or visits, many of which are consequences of caries that began when they were preschoolers.[5] Describing the most extreme consequences, Casamassimo and colleagues recently summarized the human and economic costs of ECC,[6] finding reports of several deaths associated with sepsis, and noting that the number of deaths associated with anesthesia for dental treatments is unknown.

Significant strides have been made in recent years in developing and applying oral health related quality of life measures for young children. Most studies rely on caregiver reports of the impact of severe caries on their children or on the family although some studies also include self-reports from children. A study of four-year-olds with severe caries and those who were caries free in Brazil[7] reported interviews with caregivers and children's self-ratings of how they think about their teeth using a happy and sad face. Caregivers of children with severe caries (n=77) stated that their children were more likely to be absent from school (26%), were ashamed to smile (31%), and had problems eating (49%). Children with severe caries also were more likely to select the sad face (34%) compared to caries-free children (22%).

A pilot study of children (n=77) ages 35-66 months referred for treatment under general anesthesia was conducted in Montréal Canada.[8] Caregivers, interviewed before and after treatment, reported that prior to treatment, 48% of the children complained of pain, 43% had problems eating, 35% had problems sleeping and 5% had negative reports from school. After treatment, most of the problems resolved and the authors concluded that severe caries had a serious impact on the children's quality of life and that treatment eliminated many of these problems. A study in the United Kingdom[9] found that 22% of parents of children ages five and under reported at least one impact of oral conditions among their children, the most common being pain (16%) and limitations in oral function (6%).

In the United States, Filstrup et al., included self-reports from children on the impact of caries on quality of life. Forty-three percent of children, ages 36-47 months (16 of 37 children) were able to respond to questions, such as, “Do your teeth hurt you now?” and “Does a hurting tooth wake you up at night?” The authors suggest that young children can reliably assess how oral health problems affect their quality of life.[10]

A group at the University of North Carolina developed a measure for assessing quality of life impacts associated with ECC based on the domains of symptoms, function, emotional and social/family well being.[11] The most frequent impacts were pain (14.9%) and irritability (9.2%) for children and missing work for the family (20%). A group in Canada assessed the responsiveness of this scale among 101 parents of children 0-5 years attending a hospital dental clinic.[12] The greatest impacts were on child's function and parental stress. However, the results demonstrated relatively infrequent impacts on quality of life in the sample of children and their families, although the oral health problems of the children in the sample may have been relatively minor.

A common and immediate consequence of untreated dental caries on quality of life is dental pain. However, there are few studies of the epidemiology of children's dental pain. A study of Head Start children reported that among children with caries, 16.6% complained of a toothache and 8.9% cried because of a toothache.[13] Children's dental pain affects regular activities, such as eating, sleeping and playing.[14]

The direct costs of ECC are difficult to document as no information is collected on medical and dental services specifically associated with ECC, but some estimates of the cost of care are possible. The Medical Expenditures Panel Survey found that in 2006, 19.4% of children under age 5 had a dental expenditure for a total expense of $729 million in that year. Specific procedures or causes of expenses are not reported in this survey but even if only half of these expenditures were related to ECC, the costs were substantial.[15] Several studies of hospital Emergency Department visits have reported on non-traumatic dental treatment or preventable dental conditions among young children. The Texas Children's Hospital in Houston had 636 emergency room dental visits for children less than five years of age between 1997-2001 of which 73% were for non-traumatic dental problems.[16] A California study of emergency department visits showed that the rate of visits for those 0-5 years of age for preventable dental conditions ranged 189-222 per 100,000 from 2005 to 2007. [17]

Treatment of early childhood caries is expensive, often requiring extensive restorative treatment and extraction of teeth at an early age. In 1996, estimates of cost to treat a child with two to five lesions are $408 and $1,725 for those with 16-20 lesions.[18] In addition to the expenses of dental restorations, general anesthesia or deep sedation may be required because such young children lack the ability to cope with the procedures. General anesthesia to facilitate dental treatment may add anywhere between $1,500 to $6,000 to the cost of dental care.[18,19,20,21] ECC also may contribute to other health problems, such as weight loss[22]; however, this evidence is inconsistent.[23]

## Risk Factors for ECC

### Previous Caries Experience

One of the best predictors of future caries is previous caries experience.[24,25] Children under the age of 5 with a history of dental caries should automatically be classified as being at high risk for future decay. However, the absence of caries is not a useful caries risk predictor for infants and toddlers because, even if these children are at high risk, there may not have been enough time for carious lesion development. Since white spot lesions are the precursors to cavitated lesions they will be apparent before cavitations. These white spot lesions are most often found on enamel smooth surfaces close to the gingiva. Although only a few studies have examined staining of pits and fissures[26] or white spot lesions[27] as a caries risk variable, such lesions should be considered equivalent to caries when determining caries risk in young children.

### Microbiologic Factors

Mutans streptococci (MS) are the group of microorganisms most associated with the dental caries process and key to the understanding of caries in preschool children. MS contribute to caries formation with their increased ability to adhere to tooth surfaces, produce copious amounts of acid, and survive and maintain metabolism at low pH conditions.[28] Colonization of a child's oral cavity with MS is generally the result of transmission of these organisms from the child's primary care giver.[29] Factors influencing colonization include frequent sugar exposure in the infants and habits that allowed salivary transfer from mother to infants. Maternal factors, such as high levels of MS, poor oral hygiene, low socio-economic status, and frequent snacking, contribute to this maternal transfer.[25]

Pre-school children with high colonization levels of MS have greater caries prevalence, as well as a much greater risk for new lesions than those children with low levels of MS.[30] Additionally, colonization with MS at an early age is an important factor for early caries initiation.[31,32] Reports show that predentate children can be colonized with MS as early as six months of age[33]. A further understanding of the time of MS colonization may be appreciated from

epidemiologic findings[1], and clinical observations (Figure 1) that show detection of carious lesions in populations at or before the first birthday. Since colonization of MS must precede cavity formation, it seems likely that MS colonization, at least in high-risk populations, can occur before 12 months of age.

## Visible Plaque

Studies demonstrate a correlation between visible plaque on primary teeth and caries risk.[34] One study found that that 91% of the children are correctly classified as to caries risk solely based on the presence or absence of visible plaque.[35] Most interesting is a recent study of 39 children, aged 12 to 36 months that found a positive correlation between the baseline MS and plaque regrowth, suggesting that the presence of plaque on the anterior teeth of young children is related to MS colonization.[36] The potential for visible plaque to be an accurate predictor of caries risk and MS colonization in young children is encouraging since this screening method is relatively easy.

## Dietary Factors

There is abundant epidemiological evidence that dietary sugars, especially sucrose, are a factor affecting dental caries prevalence and progression.[37] The acid production from sucrose metabolism disrupts the balance of the microbial community, favoring the growth of mutans streptococci and lactobacilli[38]; and sucrose is a unique cariogenic carbohydrate because it also serves as a substrate for extracellular glucan synthesis.[39] Glucan polymers are believed to enable MS to both adhere firmly to teeth and to inhibit diffusion properties of plaque[40], or increase plaque porosity resulting in greater acid production adjacent to the tooth surface.[41] Yet, a systematic literature review of caries risk due to sugar consumption has concluded that the relationship between sugar consumption and caries is weaker in an era of fluoride exposure.[42]

The intensity of caries in preschool children, however, may be due to frequent sugar consumption. High frequency sugar consumption enables repetitive acid production by cariogenic bacteria that are adherent to teeth. Four cohort studies of preschool children from the age of 1 to 5 years found that daily consumption of sugar-containing drinks, especially during night, and daily sugar intake were independent risk factors in the development of ECC.[43,44,45,46]

## Enamel Developmental Defects

Lack of enamel maturation or the presence of developmental structural defects in enamel may increase the caries risk in preschool children. Such defects enhance plaque retention, increase MS colonization, and in severe cases, the loss of enamel enables greater susceptibility to tooth demineralization. A strong correlation is found between presence of enamel hypoplasia and high counts of MS.[47] Enamel defects in the primary dentition are most associated with pre-, peri- or post-natal conditions such as low birth weight, and child's or mother's malnutrition or illness.[48] In the primary dentition, the prevalence of enamel defects is common, ranging from 13-39 percent in normal full-term infants [49,50,51], to over 62 percent in those born preterm with very low birth weight.[50] Enamel hypoplasia of primary incisors in poor, urban populations in the U.S. has been reported to be over 50%[52], leaving children vulnerable to the caries process.

## Socioeconomic Status

Consistent evidence supports a strong association between family income and caries prevalence. Preschool children from low-income families are more likely to have caries.[53, 54] However, children from higher income levels may have lower prevalence of caries

experience, but when they develop caries, the severity of the disease is similar to that of low income children.[4]

## Psychosocial Risk Factors

Despite the consistent evidence demonstrating the importance of socioeconomic status on ECC risk, the understanding of the underlying mechanisms that account for these disparities is limited. Similarly, psychosocial and environmental factors implicated in the development of dental disease are not well understood, including parenting stress, social support, caregiver perceived self-efficacy and neighborhood issues.

The association between stress and chronic illness is well established in the medical literature. However, the relationship between stress and dental caries is equivocal. Studies of caregiver stress and caries risk among young children have shown varying results.[55,56,57] In contrast, Finlayson et al., 2007 found that lower parental stress is associated with greater risk of ECC when adjusting for other factors.[55] Longitudinal and causal modeling approaches are needed to further investigate the role that parental stress plays in ECC risk.

Social support also has received considerable attention in the general health literature, whereby social support and social integration reduce the adverse effects of many health conditions and contribute to positive well-being, improved quality of life and greater longevity.[58] Social support has received less attention in the oral health literature and relatively little in studies of ECC. Reports from the Detroit Dental Health Project, a longitudinal study of low-income African American children and their caregivers, consistently demonstrate the importance of individual level, as well as neighborhood level, social support on reducing caries risk and in predicting caries progression among young children.[55] Findings from this study suggest that the development of more formal sources of support may be warranted.

Theories of self-efficacy postulate that a person's belief or confidence in their ability to perform certain actions influences the decision to perform these actions.[59] Self-efficacy has been found to be strongly associated with people's decision to engage in a broad range of health behaviors. A study of low income African American caregivers in Detroit investigated the effects of perceived self efficacy about tooth brushing and perceived fatalism about children developing tooth decay. Scores on the perceived self-efficacy were fairly high indicating strong caregivers' beliefs in their ability to brush their children's teeth. However, about 80% of these caregivers also believed that most children will develop dental cavities[55].

## Socio-cultural Factors

Ethnic minorities and new immigrants experience oral health disparities for many reasons beyond ability to pay for care. A recent review of health disparities in the Veterans Affairs Health System, consistent with the current literature, suggests that the underlying problems are, in part, cultural differences in how health care providers interact with ethnic minority patients, levels of patient trust, how patients think about the etiology, course and outcomes of disease as well as access to social resources.[60] A small focus group study of cultural beliefs and children's oral health care among African American, Chinese, Latino and Filipino caregivers found that health beliefs concerning the cause of disease, community beliefs about fear of dental care and knowledge about oral health care influenced use of dental services.[61] These findings reinforce the views put forth by Garcia et al. on the importance of cultural competence.[62] More work is needed is to understand the cultural competency of dental care providers, improve communication skills and address the limitations in oral health literacy among people at the greatest risk of poor oral health.

### Utilizing Risk Factors

Strategies for managing caries in preschool children increasingly have emphasized the concept of risk assessment for clinical decision making as well as to better understand the disease process in a specific individual. Table 1 incorporates available evidence into a non-validated tool that may assist health care providers in assessing levels of caries risk for preschool children. As new evidence emerges, certainly tools such as this will be further refined.

## Interventions to Reduce ECC

As we have seen, there has been an increase in our knowledge regarding the risk factors for early childhood caries, but interventions to reduce the disease have been less successful. Clinical trials on infants and toddlers are challenging and difficult to accomplish for several reasons. Populations of young children at risk for dental caries are difficult to recruit because they are not enrolled in large numbers in institutional settings. Parents of young children, especially those in low socioeconomic settings, have difficulty in complying with the interventions, and often drop out of clinical trials. Furthermore, institutional review boards are cautious to approve studies in very young children and make demands on the study design, such as not allowing untreated control groups and requiring that treatment must be assured for children identified with disease. However, data from current peer-reviewed literature and expert panels suggest appropriate interventions to reduce ECC (Table 2).

### Tooth Brushing with Fluoridated Toothpaste

The role of tooth brushing in the prevention of tooth decay has long been considered self-evident. Yet there is little evidence to support the notion that tooth brushing per se reduces caries. The relationship between individual oral hygiene status and caries experience is weak and instructional programs designed to reduce caries incidence by promoting oral hygiene have failed.[63,64,65] However, convincing evidence exists for the decay-preventing benefit of tooth brushing with fluoride-containing toothpaste.[66] Three clinical trials have shown that daily tooth brushing with fluoride toothpaste in 3-6 year olds significantly reduces caries incidence.[67, 68,69] To prevent dental fluorosis from excessive swallowing of toothpaste, children's brushing should be supervised with dispensing only a “smear” of fluoridated toothpaste for children less than 2 years, and a “pea-size” amount of toothpaste for children aged 2 through 5 years.[70]

### Systemic Fluoride Supplements

If the fluoride content of water is sub-optimal or unknown, the drinking water can be analyzed for fluoride content, and systemic fluoride supplementation can be recommended based on the fluoride content of the water, the child's age, as well as the child's caries risk. Data from over 20 clinical trials show caries' reduction in primary teeth of 30-80% from fluoride supplements, provided that they are started close to birth and continued for five or more years.[71] However, these studies were done in the 1950 - 60s, when research designs may not have been as rigorous, and children living in non-fluoridated area were receiving less fluoride from dentifrice, beverages and foods.[72] Because of the risk of fluorosis, CDC recommendations suggest that fluoride supplements should be prescribed only to children residing in non-fluoridated communities, who are identified as being at high caries risk.[73] Fluoride supplementation is not recommended as the first-line preventive approach due to compliance issues, lack of information about the fluoride status of the child's drinking water and the child's caries risk status.[74]

### Fluoride Varnish

Fluoride varnish is ideally suited for topical applications to the teeth of preschool children because of ease of use, acceptability to young children and reduced risk of over ingestion of

fluoride. Commercially, these varnishes generally come in single use dispensers that limit the quantity of fluoride application to either 5.6, 9.0, 13.6 mg F, corresponding to 0.25, 0.4 and 0.6 ml varnish in the dispenser. Their efficacy to reduce caries in primary teeth has been shown in several studies.[75,76,77,78,79] The American Dental Association's 2006 topical fluoride guidelines recommended that fluoride varnish be applied every six months for those preschool children at moderate caries risk, and every three to six months for children at high risk.[80]

The American Academy of Pediatrics has endorsed the use of fluoride varnishes by pediatricians and such recommendations are reimbursed by Medicaid in more than 25 States. However, as of 2002, no studies assessed the appropriateness (familiarity with the procedures, patient selection, and adherence to clinical protocols) of primary care physicians' use of topical fluoride.[81]

## Counseling to Reduce Harmful Behaviors

Good data show that children's oral cavity is colonized with MS generally as result of their transmission from the child's primary care giver. As a result of these findings there have been at least eleven reports of interventions on mothers using various combinations of treatments, including antimicrobial agents, fluoride, xylitol chewing gum and restorative care in order to reduce MS and consequently caries in their offspring.[29] Most studies found a reduction of MS in their children, but only two showed significant caries reduction. The efficacy of caregivers' preventing MS transmission to their child by proper hygiene practices that reduces the transmission of MS still needs to be established.

Nutritional counseling for the purpose of reducing caries incidence in children is aimed primarily at teaching parents the importance of reducing frequent sugar exposures. Two Swedish studies have tested the effect of preventive education for new mothers on the subsequent caries experience of their children. One study provided diet and oral hygiene counseling to the test group at 6, 12 and 24 months of age, as well as fluoride supplements. This study observed a 65% lower caries experience in the 4-year-old children of mothers who received counseling as compared to the control group.[82] Another study with a similar program found a 42% decrease in caries prevalence after 4 years.[83] Although the results of these studies are encouraging, it is not clear why there have not been more studies to explore the potential of dietary counseling in reducing dental caries in preschool children.

A Canadian study among Vietnamese preschool children in Vancouver assessed the effectiveness of lay community workers in one-on-one counseling during well-child visits to the health clinic. Mothers who had more than one counseling visit reported less use of day-time and sleep-time bottles and their children had lower prevalence of dental caries.[61] In another study, children of parents exposed to motivational interviews had 63% fewer new carious lesions than those parents exposed to traditional health education.[84] Motivational interviewing to help parents change behaviors and adopt preventive dental recommendations merits further investigation.

## Dental Referral

For those children that are at caries risk, MS colonization and the carious process often begin before the first birthday. Therefore, a dental referral consisting of examination of the teeth, anticipatory guidance counseling, performing preventive procedures and establishing a “dental home” has recommended for all infants at 12 months.[85,86] Yet, the capacity of dental providers willing to see infants is fixed, and if such services were implemented among all one-year-olds, those children identified with caries risk may be “crowded out” and not receive care.[87] Thus from a public health perspective, it may be prudent not to recommend dental referral at age one for children at low caries risk.

## Conclusions

Although ECC is a significant health problem, little emphasis was placed on this disease before the SGROH, perhaps because of the difficulty in conducting dental studies in young children. ECC remains a major health problem in the U.S. with a prevalence of 50% in poor and near poor five-year-olds. This disease has increased in the past 10 years and is mostly untreated in preschool children.

Strategies for managing dental caries in young children increasingly have emphasized identification of children at risk and individual assessment of caries risk factors. Risk assessment tools are still being developed and tested. However, caries risk indicators that are currently accepted as important include a child's fluoride exposure from various sources, the way sugar containing foods are consumed, the socioeconomic status of the family, the caries experience of others in the family, previous caries experience, visible plaque on teeth, and mutans streptococci levels.

Currently, interventions to reduce ECC have been only partially successful, and many barriers to conducting such studies persist. Several reports have shown that daily tooth brushing with fluoride tooth paste, as well as application of fluoride varnish reduces caries incidence in preschool children. Such topical fluoride applications are becoming more popular to prevent ECC than systemic fluoride supplements. Recent reports also show that motivational interviews with parents of preschool children that include diet counseling may affect caries prevalence in their children.

Certainly, progress has been made in the past few years, but significant work is needed to better understand the biological and socio-demographic factors, and the preventive strategies to treat this disease

## Acknowledgments

Supported in part by NIH/NIDCR 1U54DE019275. Center for Research to Evaluate and Eliminate Dental Disparities. The authors would like to thank the assistance of Drs. William Maas, Alan Douglass and Joanna Douglass for suggestions and review of this manuscript.

## References

1. Tang J, Altman DS, Robertson D, O'Sullivan, et al. Dental caries prevalence and treatment levels in Arizona preschool children. Public Health Reports 1997;112:319–329. [PubMed: 9258297]
2. Drury TF, Winn DM, Snowden CB, et al. An overview of the oral health component to the 1988-91 National Health and Nutrition Examination Survey (NHANES III, phase 1). J Dent Res 1996;75 (special issues):620–30. [PubMed: 8594086]
3. Dye BA, Tan S, Smith V, et al. Trends in oral health status: United States, 1988-1994 and 1999-2004. National Center for Health Statistics Vital Health Stat 2007;11:248.
4. Tinanoff N, Kanellis M, Vargas C. Current understanding of epidemiology, mechanisms and prevention of dental caries in preschool children. Pediatric Dentistry 2002;24:543–551. [PubMed: 12528947]
5. Gift HC, Reisine ST, Larach PC. The social impact of dental problems and visits. Am J Pub Hlth 1992;82:1663–1668.
6. Cassamassimo PS, Thikkurissy S, Edelstein BL, Maiorini E. Beyond dmft: The human and economic cost of early childhood caries. JADA 2009;140:650–657. [PubMed: 19491160]
7. Feitosa S, Colares V, Pinkham J. The psychosocial effects of severe caries in 4-year-old children in Recife, Pernambuco, Brazil. Cad Saude Publica 2005;21:1550–1556. [PubMed: 16158161]
8. Low W, Tan S, Schwartz S. The effect of severe caries on the quality of life in young children. Pediatr Dent 1999;21:325–326. [PubMed: 10509332]

9. Nuttall NM, Steele JG, Evans D, et al. The reported impact of oral condition on children in the United Kingdom, 2003. Br Dent J 2006;200:551–555. [PubMed: 16732242]
10. Filstrup SL, Briskie D, da Fonseca M, et al. Early childhood caries and quality of life: child and parent perspectives. Pediatr Dent 2003;25:431–440. [PubMed: 14649606]
11. Pahel TB, Rozier RG, Slade G. Parental perceptions of children's oral health: The Early Childhood Oral Health Impact Scale. Hlth Qual Life Outcomes 2007;5:6–16.
12. Li S, Malkinson S, Allison PJ. Testing responsiveness to change for the early childhood oral health impact scale (ECOHIS). Community Dent Oral Epidemiol 2008;36:542–48. [PubMed: 18422706]
13. Vargas CM, Monajemy N, Khurana P, et al. Oral health status of preschool children attending Head Start in Maryland, 2000. Pediatric Dent 2002;24:257–263.
14. Edelstein BA, Vargas CM, Candelaria D, et al. Characteristics of children visiting emergency rooms at dental schools. Pediatric Dent 2006;28:431–437.
15. Agency for Healthcare Research and Quality. Dental Services-Mean and Median Expenses per Person with Expense and Distribution of Expenses by Source of Payment: United States, 2006. Medical Expenditure Panel Survey Component Data. July 06;2009 Generated interactively
16. Ladrillo TE, Hobdell MH, Caviness C. Increasing prevalence of emergency department visits for pediatric dental care 1997-2001. JADA 2006;137:379–85. [PubMed: 16570472]
17. California Health Care Foundation; 2009 [July 2, 2009]. Emergency Department Visits for Preventable Dental Conditions in California. Available at: http://www.chcf.org
18. Ramos-Gomez F, Huang G, Masouredis C, et al. Prevention and treatment costs of infant caries in Northern California. J Dent Child 1996;63:108–112.
19. Griffin SO, Gooch BR, Beltran E, et al. Dental services, costs, and factors associated with hospitalization for Medicaid-eligible children, Louisiana 1996-7. J Pub Hlth Dent 2000;60:21–27.
20. Kanellis MJ, Damiano PC, Momamy ET. Medicaid cost associates with hospitalization of young children for restorative dental treatment under general anesthesia. J Pub Hlth Dent 2000;60:28–32.
21. Duperon DF. Early childhood caries: a continuing dilemma. J Calif Dent Assoc 1995;23:15–25. [PubMed: 7643181]
22. Acs G, Lodolini G, Kaminsky S, et al. Effect of nursing caries on body weight in a pediatric population. Pediatr Dent 1992;14:302–305. [PubMed: 1303533]
23. Thomas CW, Primosch RE. Changes in incremental weight and well-being of children with rampant caries following complete dental rehabilitation. Pediatr Dent 2002;24:109–113. [PubMed: 11991312]
24. Reisine S, Litt M, Tinanoff. A biopyschosocial model to predict caries in preschool children. Pediatr Dent 1994;16:413–18. [PubMed: 7854947]
25. Birkeland JM, Broch L, Jorkjend L. Caries experience as predictor for caries incidence. Community Dent Oral Epidemiol 1997;4:66. [PubMed: 1062253]
26. Steiner M, Helfenstein U, Marthaler TM. Dental predictors of high caries increment in children. J Dent Res 1992;71:1926–1933. [PubMed: 1452896]
27. van Palenstein Helderman WH, van't Hof MA, van Loveren C. Prognosis of caries increment with past caries experience variables. Caries Res 2001;35:186–192. [PubMed: 11385198]
28. Loesche WJ. Role of Streptococcus mutans in human dental decay. Microbial Rev 1969;50:353–380.
29. Douglass JM, Li Y, Tinanoff N. Literature review of the relationship between mutans streptococci in adult caregivers and mutans streptococci and dental caries in their children. Pediatric Dentistry 2008;30:375–387. [PubMed: 18942596]
30. Wan AKL, Seow WK, Purdie DM, et al. Oral colonization of Streptococcus mutans in six-month-old predentate infants. J Dent Res 2001;80:2060–2065. [PubMed: 11808762]
31. Thibodeau EA, O'Sullivan DM. Salivary mutans streptococci and dental caries patterns in pre-school children. Community Dent Oral Epidemiol 1996;24:164–168. [PubMed: 8871013]
32. Alaluusua S, Renkonen OV. Streptococcus mutans establishment and dental caries experience in children from 2 to 4 years old. Scand J Dent Res 1983;91:453–457. [PubMed: 6581521]
33. Masuda N, Tsutsumi N, Sobue S, et al. Longitudinal survey of the distribution of various serotypes of Streptococcus mutans in infants. J Clin Microbiol 1979;10:497–502. [PubMed: 528682]

34. Alaluusua S, Malmivirta R. Early plaque accumulation – a sign for caries risk in young children. Community Dent Oral Epidemiol 1994;22:273–276. [PubMed: 7813174]
35. Alanen P, Hurskainen K, Isokangas P, et al. Clinician's ability to identify caries risk subjects. Community Dent Oral Epidemiol 1994;22:86–9. [PubMed: 8205785]
36. Lee CL, Tinanoff N, Minah G, et al. Effect of mutans streptococci colonization on plaque formation and regrowth. J Pub Hlth Dentistry 2008;68:57–60.
37. Rugg-Gunn, AJ. Diet and dental caries. In: Murray, JJ., editor. Prevention of Oral Disease. Oxford: Oxford University Press, Oxford; 1966. p. 3-31.
38. Marsh PD. Sugar, fluoride, pH and microbial homeostasis in dental plaque. Proc Fin Dent Soc 1991;87:515–525.
39. Newbrun E. Sucrose, the arch criminal of dental caries. Odontol Revy 1967;18:373–386. [PubMed: 5234965]
40. Tanzer, JM. Microbiology of dental caries. In: Slots, J.; Taubman, MA., editors. Contemporary Oral Microbiology and Immunology. St Louis: Mosby Year Book; 1992. p. 377-424.
41. Zero. Sugars—the arch criminal? Caries Res 2004;38:277–285. [PubMed: 15153701]
42. Burt BA, Pai S. Sugar consumption and caries risk: A systematic review. J Dent Educ 2001;65:1017–1023. [PubMed: 11699972]
43. Grindefjord M, Dahloff G, Nilsson B, et al. Stepwise prediction of dental caries in children up to 3.5 years of age. Caries Res 1996;30:256–266. [PubMed: 8773417]
44. Wendt LK, Hallonsten AL, Koch G, et al. Analysis of caries related factors in infants and toddlers living in Sweden. Acta Odontologica Scandinavica 1996;54:131–137. [PubMed: 8739147]
45. Rodrigues CS, Sheiham A. The relationship between dietary guidelines, sugar intake and caries in primary teeth in low-income Brazilian 3-year-olds: a longitudinal study. Int J Ped Dent 2000;10:47–55.
46. Karjalainen S, Soderling E, Sewon L, et al. A prospective study on sucrose consumption, visible plaque and caries in children 3 to 6 years of age. Community Dent Oral Epidemiol 2001;29:136–142. [PubMed: 11300173]
47. Li Y, Navia JM, Caufield PW. Colonization by mutans streptococci in the mouths of 3- and 4-year-old Chinese children with or without enamel hypoplasia. Arch Oral Biol 1994;39:1057–1062. [PubMed: 7717887]
48. Seow WK. Enamel hypoplasia in the primary dentition: A review. J Dent Child 1991;58:441–452.
49. Seow WK, Humphrys C, Tudehope DI. Increased prevalence of developmental defects in low-birth-weight children: A controlled study. Pediatr Dent 1987;9:221–225. [PubMed: 3507638]
50. Grahnen H, Larsson PG. Enamel defects in deciduous dentition of prematurely- born children. Odontol Revy 1958;9:193–204.
51. Nino De Guzman P, Minah GE, Jodrey DB, et al. Recording of enamel hypoplasia and ECC at the D1-D4 levels. J Dent Res 2001;80:132.
52. Abernathy JR, Graves RC, Bohannan HM, et al. Development and application of a prediction model for dental caries. Community Dent Oral Epidemiol 1987;15:24–28. [PubMed: 3467890]
53. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1998-1994. J Am Dent Assoc 1998;129:1229–1241. [PubMed: 9766104]
54. Beck JD. Risk revisited. Community Dent Oral Epidemiol 1998;26:220–25. [PubMed: 9758421]
55. Finlayson TL, Siefert K, Ismail AI, et al. Psychosocial factors and early childhood caries among low-income African-American children in Detroit. Community Dent Oral Epidemiol 2007;35:439–48. [PubMed: 18039285]
56. Quiñonez RB, Keels MA, Vann WF, et al. Early childhood caries:Analysis of psychosocial and biological factors in a high-risk population. Caries Res 2001;35:376–83. [PubMed: 11641574]
57. Tang C, Quinonez RB, Hallett K, et al. Examining the association between parenting stress and the development of early childhood caries. Community Dent Oral Epidemiol 2005;33:454–460. [PubMed: 16262613]
58. Cohen, S.; Underwood, LG.; Gottlieb, B., editors. Social Support Measurement and Intervention: A Guide for Health and Social Scientists. Oxford: Oxford University Press; 2000.
59. Bandura, A. Social Foundations of Thought and Action. New York: Prentice-Hall; 1986.

60. Saha S, Freeman M, Toure J, et al. Racial and ethnic disparities in the VA health care system: a systematic review. J Gen Intern Med 2008;23:654–671. [PubMed: 18301951]
61. Harrison R. Oral health promotion for high-risk children: Case studies from British Columbia. J Cand Dent Assoc 2003;69:292–296.
62. Garcia RI, Cadoret CA, Henshaw M. Multicultural issues in oral health. Dent Clin N Am 2008;52:319–332. [PubMed: 18329446]
63. Andlaw RJ. Oral hygiene and dental caries: a review. Int Dent J 1978;28:1–6. [PubMed: 346493]
64. Bibby BG. Do we tell the truth about preventing caries? J Dent Child 1966;33:269–79. [PubMed: 5331542]
65. Heifetz SB, Bagramian RA, Suomi JD, et al. Programs for the mass control of plaque: an appraisal. J Public Health Dent 1973;33:91–5. [PubMed: 4512650]
66. Burt, BA.; Eklund, SA. Dentistry, Dental Practice, and the Community. Vol. 5th. Philadelphia: W.B. Saunders Company; 1999.
67. Schwarz E, Lo ECM, Wong MCM. Prevention of early childhood caries – results of a fluoride toothpaste demonstration trial on Chinese preschool children after three years. J Public Health Dent 1998;58:12–18. [PubMed: 9608441]
68. Holtta P, Alaluusua S. Effect of supervised use of a fluoride toothpaste on caries incidence in preschool children. Int J Paediatr Dent 1992;2:145–149. [PubMed: 1304804]
69. Sjögren K, Birkhed D, Rangmar B. Effect of a modified toothpaste technique on approximal caries in preschool children. Swed Dent J 1995;110(suppl):1–10.
70. American Academy of Pediatric Dentistry Reference Manual. Policy on Use of Fluoride. Pediatric Dentistry 2007;29:34–35.
71. Driscoll, WA. The use of fluoride tablets for the prevention of dental caries. In: Forrester, DJ.; Schulz, EM., Jr, editors. International Workshop on Fluorides and Dental Caries Reduction; Baltimore. University of Maryland; 1974. p. 25-96.
72. Levy SM, Guha-Chowdhury N. Total fluoride intake and implications for dietary fluoride supplementation. J Pub Health Dent 1999;59:211–23. [PubMed: 10682326]
73. Morbidity and Mortality Weekly Report. 2001. Recommendations for using fluoride to prevent and control dental caries in the United States Vol. 50/No. RR-14. August 17;
74. Tinanoff, N. Use of Fluorides, in Early Childhood Oral Health. Berg, J.; Slayton, RA., editors. Blackwell and Munksgaard; 2009.
75. Holm AK. Effect of a fluoride varnish (Duraphat) in preschool children. Comm Dent Oral Epidemiol 1979;7:241–5.
76. Frostell G, Birkhed D, Edwardsson S, et al. Effect of partial substitution of invert sugar for sucrose in combination with Duraphat treatment on caries development in preschool children: The Malmo study. Caries Res 1991;25:304–10. [PubMed: 1913770]
77. Twetman S, Petersson LG, Pakhomov GN. Caries incidence in relation to salivary mutans streptococci and fluoride varnish applications in preschool children from low- and optimal-fluoride areas. Caries Res 1996;30:347–53. [PubMed: 8877088]
78. Autio-Gold JT, Corts F. Assessing the effect of fluoride varnish on early enamel carious lesions in the primary dentition. J Am Dent Assoc 2001;132:1247–1253. [PubMed: 11665349]
79. Weintraub JA, Ramos-Gomes F, Jue B, et al. Fluoride varnish efficiency in preventing early childhood caries. J Dent Res 2006;85:172–176. [PubMed: 16434737]
80. Hunter JW, Chan JT, Featherstone DB, et al. Professionally Applied Topical Fluoride: Evidence-Based Clinical Recommendations. JADA 2006;137:1151–1159. [PubMed: 16873333]
81. Bader, JD.; Rozier, G.; Harris, R., et al. Dental Caries Prevention: The physician's role in child oral health systemic evidence review. Dec2002 [July 14, 2006]. Available at: http://www.ahrq.gov/downloads/pub/prevent/pdfser/dentser.pdf
82. Holst K, Kohler L. Preventing dental caries in children: Report of a Swedish program. Devel Med Child Neur 1975;17:602–604.
83. Holm AK, Blomquist HK, Grossner GG, Grahnen H, Samuelson G. A comparative study of oral health as related to general health, food habits and socio-economic condition of 4-year-old Swedish children. Community Dent Oral Epidemiol 1975;3:34–39. [PubMed: 1053970]

84. Weinstein P, Harrison R, Benton T. Motivating parents to prevent caries in their young children. One-year findings. JADA 2004;135:731–738. [PubMed: 15270155]

85. American Academy of Pediatric Dentistry Reference Manual. Guideline on Infant Oral Health Care. Pediatric Dentistry 2007;29:81–84.

86. American Dental Association. Care for your infant. [August 12, 2009]. Available at: www.ada.org/public/manage/stages/parents.asp#care

87. Jones K, Tomar SL. Estimated impact of competing policy recommendations for age of first dental visit. Pediatrics 2005;115:906–914. [PubMed: 15805363]

88. ADA Caries Risk Assessment Forms. [February 30, 2009]. Available at: www.ada.org/prof/resources/topics/topics_caries_under6.doc and over6.doc

**Figure 1.**
Carious lesions in a 12-month-old child that suggests that at least in some children MS colonization and the carious process begins before a child first birthday.

## Table 1

Caries risk assessment for children, ages 0-6 (adapted from reference 88).

| | Low Risk | Moderate Risk | High Risk |
|---|---|---|---|
| Fluoride Exposure (through drinking water, supplements, professional applications, toothpaste) | Yes | No | No |
| Sugary Foods or Drinks (including juice, carbonated or non-carbonated soft drinks, medicinal syrups) | Consumed primarily at mealtimes | Frequent or prolonged between meal exposures | Bottle or sippy cup with sweetened beverages as pacifying drink |
| Socio-Economic Status | Non-poor | Near-poor | Poor |
| Caries Experience of Mother, Caregiver and/or Other Siblings | No dental problems, has regular dentist | Receiving treatment for dental caries | Untreated dental caries, no source of dental care |
| Special Health Care Needs* | No | Yes, depends on condition | Yes, depends on condition |
| White Spot Lesions, Enamel Defects, Restorations or Cavitated Carious Lesions | None | | Yes |
| Plaque | No visible plaque | | Visible plaque |
| Mutans Strepococcus | Low | Moderate | High |

This table can be used as a checklist for the health care worker and parent. Circling those conditions that apply to a specific patient prompts a discussion of the factors that contribute to or protect from caries and interventions that are needed (Table 2). Risk assessment categorization of low, moderate or high is based on preponderance of factors for the individual. However, clinical judgment may justify the use of one factor in determining overall risk, for instance, frequent exposure sugar containing snacks of beverages, or visible cavities.

Overall assessment of the child's dental caries risk High □ Moderate □ Low □

## Table 2

Caries management approaches to reduced early childhood caries by risk category.

| | Low Risk | Moderate Risk | High Risk |
|---|---|---|---|
| Toothbrushing with Fluoridated Toothpaste [α] | Yes | Yes | Yes |
| Systemic Fluoride Supplements [β] | No | Consider | Consider |
| Fluoride Varnish | No | At least every 6 months | Every 3 months |
| Counseling to Reduce High Frequency Sugar Exposure | Yes | Yes | Yes |
| Dental Referral | No later than age 3 | Age 1 | Age 1 |

[α] "Smear" of toothpaste for children under age 2; "pea-size" over age 2; twice daily.

[β] Patient's age, parent's compliance and knowledge of fluoride levels in tap water considerations.