Scientific Article

Current understanding of the epidemiology, mechanisms, and prevention of dental caries in preschool children

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Abstract

The seriousness and societal costs of dental caries in preschool children are enormous. National data shows that caries is highly prevalent in poor and near poor US preschool children, yet this disease is infrequently treated. The etiology includes elevated colonization levels of mutans streptococci, high frequency sugar consumption, and developmental defects on primary teeth. A necessary first step in preventing dental caries in preschool children is evaluating the child's caries risk factors that include socioeconomic status, previous carious experience, presence of white spot lesions, presence of visible plaque, perceived risk by dental professionals, and microbiologic testing for the presence or quantity of mutans streptococci. Based on this knowledge, different preventive strategies, as well as different intensities of preventive therapies, can be employed. Caries preventive strategies in preschool children include diet modifications to reduce high frequency sugar consumption, supervised tooth brushing with fluoridated dentifrice, systemic fluoride supplements to children living in a nonfluoridated area that are at risk for caries, professional topical fluoride with fluoride varnish, and sealants for primary molars.(*Pediatr Dent.* 2002;24:543-551)

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Epidemiology

Although dental caries is known to be a significant problem in preschool populations, comprehensive understanding of its epidemiology is limited due to the difficulty in accessing this age group for data collection purposes. In the United States, most studies of caries prevalence in preschool populations are derived from convenience samples of Head Start and WIC populations that may be at higher caries risk than the general population. An overview of studies from 3- to 5-year-old Head Start children in the last 10 years shows dental caries ranging from 1.34 dmft (decayed, missing, and filled teeth) in a Mississippi study to 8.33 dmft in a Native American Arizonan population.[1]

A better understanding of the epidemiology of caries in preschool children can be derived from the Third National Health and Nutrition Examination Survey (NHANES III) conducted between 1988-1994 that provides data from dental examinations of 4,300 2- to 5-year-old children. This national study is more reliable than other surveys because of its large sample size, national representativeness, and careful standardization of examiners.[2] Furthermore, because it includes socioeconomic factors, insights can be derived regarding the prevalence of dental caries and its treatment in US preschool children at various income levels.

This NHANES data also shows that the number of decayed or filled teeth (dft) is high in US preschool children (Table 1).

Poor and near poor 2 year olds have an average of half a dft per child. The prevalence of lesions is greater in subsequent age groups, with the poor and near poor 5-year-old children having 2.7 dft. In contrast, the nonpoor 5 year olds' mean dft is less than 1. When the dft is calculated for only those children with caries experience, the severity of disease in those children affected can be comprehended. For instance, irrespective of economic setting, 2-year-old children with caries have more than 3 lesions per child. Differences in dft between economic levels are also less in affected 3 and 5 year olds. Thus, overall nonpoor children have on average fewer lesions, but when they are affected by caries, the disease severity is similar to that of poor and near poor children.

Table 2 shows the percentage of preschool children with caries experience and untreated decay by poverty status. More than 10% of poor and near poor 2 year olds have caries; more than half of the poor and near poor 5 year olds have caries. The disease is essentially untreated in the 2 and 3 year olds, as shown by the lack of differences between percentages of caries experience and percentages of untreated decay. Between 63%-75% of the caries is still untreated in

the 5 year olds. Therefore, data from NHANES III clearly indicates that: (1) Caries is highly prevalent in poor and near poor US preschool children.[3] (2) Those children with caries experience, irrespective of income status, have high numbers of teeth affected. (3) Dental caries in US preschool children is infrequently treated.[3]

Carious process

Microbiologic factors

Mutans streptococci (MS) are the group of microorganisms most associated with the dental caries process and the key to the understanding of caries in preschool children. MS are believed to contribute to caries because of their ability to adhere to tooth surfaces, produce copious amounts of acid, and survive and continue metabolism at low pH conditions (for review, see reference 4). Colonization of the oral cavity with MS in children is generally the result of transmission of these organisms from the child's primary caregiver, usually the mother.[5,6] The exact method of transmission is not known, but it is suspected to be due to close maternal-child contact and sharing of food and utensils.

Preschool children with high colonization levels of MS have been shown to have greater caries prevalence, as well as a much greater risk for new lesions than those children with low levels of MS.[7] Additionally, colonization with MS at an early age is an important factor for early caries initiation. Several studies have shown that the earlier MS is detected in children, the higher the caries experience.[8,9].

Data on when a child is colonized by MS is contradictory, but the time of colonization is important to understanding both caries-risk factors and the time that preventive measures should be implemented. One study reported detectable MS in plaque from children as young as 13 months old and in 40% of the children by the age of 2 years.[9] A second study reported detectable MS in 7% of children 4 to 13 months old.[10] A third study reported that 6% of 1 year olds were colonized with MS[11]; one reported that MS colonization in children using a baby bottle occurred as early as 10 months of age.[12] In contrast, a well-known study reported a "window of infectivity" in which the acquisition of MS occurs between 19 and 31 months of age.[13]

There are recent reports that show that predentate children can be colonized with MS. Factors found which influenced colonization were 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 socioeconomic status, and frequent snacking, contribute to this

Table 1. Mean Decayed and Filled Teeth (dft) in Preschool Children by Poverty Status*

Age	Poor† dft (SE)	Near poor dft (SE)	Nonpoor dft (SE)
All children			
2 y	0.5 (0.08)	0.4 (0.12)	‡
3 y	1.1 (0.18)	1.1 (0.36)	0.3 (0.10)
4 y	1.8 (0.29)	1.3 (0.20)	0.5 (0.12)
5 y	2.7 (0.35)	2.7 (0.47)	0.8 (0.16)
Children with caries experience			
2 y	3.0 (0.23)	3.8 (0.59)	3.6 (0.54)
3 y	3.8 (0.37)	4.8 (0.89)	4.2 (0.41)
4 y	4.6 (0.45)	4.0 (0.50)	2.8 (0.32)
5 y	4.8 (0.54)	5.2 (0.53)	3.2 (0.45)

*Third National Health and Nutrition Examination Survey, 1988-1994
†Poor: <100% federal poverty level (FPL); near poor: 100-<200% FPL; nonpoor: 200+FPL
‡Unreliable data, standard error greater than 30% of estimate

Table 2. Percentage of Preschool Children with Caries Experience (dft >0) and Percentage of Children with Untreated Decay (dt) by Poverty Status*

Age	Poor†		Near poor		Nonpoor	
	Caries experience (SE)	Untreated decay (SE)	Caries experience (SE)	Untreated decay (SE)	Caries experience (SE)	Untreated decay(SE)
2 y	17.1 (2.25)	16.5 (2.24)	10.9 (2.73)	10.7 (2.72‡	‡	‡
3 y	28.3 (4.13)	27.0 (4.13)	21.9 (4.66)	21.2 (4.47)‡	7.9 (2.04)	5.3 (1.37)
4 y	40.2 (4.29)	33.6 (4.73)	31.4 (3.29)	27.7 (3.24)	20.5 (3.55)	13.7 (2.47)
5 y	55.8 (4.49)	42.7 (4.36)	51.4 (5.12)	37.7 (5.47)	25.4 (3.30)	16.1 (2.96)

*Third National Health and Nutrition Examination Survey, 1988-1994
†Poor: <100% federal poverty level (FPL); near poor: 100-<200% FPL; nonpoor: 200+FPL
‡Unreliable data, standard error greater than 30% of estimate

maternal transfer.[14] Another report, using DNA probes for detection of bacteria in young children from Saipan, reported that the majority of these children between 6 to 18 months were colonized with MS.[15] A further understanding of the time of MS colonization may be appreciated by epidemiologic findings[1] and clinical observations (Fig 1) that show detection of carious lesions in populations at, or before the child's first birthday. Since colonization of MS must precede cavity formation, it seems likely that MS colonization, at least in high-risk populations, must occur well before 12 months of age.

Dietary factors

There is abundant epidemiological evidence that dietary sugars are the major dietary factor affecting dental caries prevalence and progression (for review, see reference 16). Sucrose appears to be the most cariogenic sugar, not only because its metabolism produces acid, but also because MS utilize this sugar to produce the extracellular polysaccharide glucan. Glucan polymers are believed to enable MS to both adhere firmly to teeth and to inhibit diffusion properties of plaque.[17]

The intensity of caries in preschool children may be due, in part, to frequent sugar consumption. High frequency sugar consumption enables copious acid production by cariogenic bacteria that are adherent to teeth. This acid can demineralize tooth structure depending on the absolute pH decrease, as well as the length of time that the pH is below the "critical pH" level. The critical pH value for demineralization varies among individuals, but is in the approximate range of 5.2 to 5.5.[18] Conversely, tooth remineralization can occur if the pH of the environment adjacent to the tooth is high due to: (1) lack of substrate for bacterial metabolism; (2) low percentage of cariogenic bacteria in the plaque; (3) elevated secretion rate of saliva; (4) strong buffering capacity of saliva; (5) presence of inorganic ions in saliva; (6) fluoride; and (7) rapid food clearance times. However, if demineralization over time exceeds remineralization, an initial carious lesion (the so-called "white spot" lesion) can develop and may further progress to a frank cavity.

The sugar alcohols (eg, sorbitol, mannitol, and xylitol) are sweeteners that either are not metabolized by bacteria or are metabolized at a slower rate. Clinical studies comparing the cariogenicity of Xylitol to fructose and sucrose show significant reductions in dental caries.[19,20] A recent study even suggests that Xylitol gum chewed by mothers reduces dental caries in their children by inhibiting the transmission of MS to their child.[21] It seems clear that these sugar alcohols have value in preventing dental caries, especially when substituted for conventional sugar in gum.

Tooth factors

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

Fig 1. Carious lesions in a 12-month-old child that may be associated with several etiologies including mutans streptococci colonization, high frequency sugar exposure, and enamel defects

enamel enables greater susceptibility to tooth demineralization. A strong correlation is found between presence of enamel hypoplasia and high counts of MS.[22] Enamel defects in the primary dentition are most associated with prenatal, perinatal or postnatal conditions such as low birth weight, and the child's or mother's malnutrition or illness (for review see reference 23). In the primary dentition, the prevalence of enamel defects are common, with the overall prevalence ranging from 13%-39% in normal full-term infants[23-25] to over 62% in those born preterm with very low birth weight.[24] Enamel hypoplasia of primary incisors in poor urban populations in the United States was reported to be over 50%.[26]

Caries-risk assessment and anticipatory guidance

A necessary first step in preventing dental caries in preschool children is to understand the caries risk. Based on this knowledge, different preventive strategies as well as different intensities of preventive therapies can be employed. Several models for caries-risk assessments that are coordinated with preventive strategies are proposed.[27,28] However, one still must be cautious about the value of caries-risk assessment in preventing dental caries because presently there are no longitudinal studies showing the effect of delivering various preventive strategies based on assigned caries risk. Risk assessment strategies that are most applicable for use in clinical practice include those that are easily performed, are inexpensive, require no special equipment or supplies, and provide reliable results. Indicators of caries risk that meet these criteria include: (1) previous caries experience; (2) presence of white spot lesions or enamel defects; (3) visible plaque; (4) perceived risk by dental professionals; (5) screening tests for MS; and (6) socioeconomic level of family.

Previous caries experience

One of the best predictors of future caries is previous caries experience.[29-33] With children under the age of 5, a history of dental caries should automatically classify a child as high risk for future decay. However, previous caries experience

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. Furthermore, the goal of caries-risk assessment in young children is to prevent caries initiation before the first signs of disease.

White spot lesions

As stated above, previous caries experience is the best predictor of future caries experience, but young children may have no cavitations simply due to the fact that the disease has not had time to express itself. However, 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 there are only a few studies that have examined staining of pits and fissures[33] or hypoplastic lesions[34] as caries-risk variables, such lesions should be considered equivalent to caries when determining caries risk in young children.

Visible plaque

The presence of visible plaque on the teeth of preschool children can be used as an indicator of caries risk. Several studies have shown that there is a correlation between visible plaque on primary teeth and caries risk.[35-37] 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.[36] The potential for visible plaque to be an accurate predictor of caries risk in very young children, therefore, is encouraging since this screening method is easy. Further study is necessary to establish the best method to measure plaque for prediction of dental caries risk in preschool children.

Perceived risk by dental professional

The ability of dentists, hygienists, and other health professionals to subjectively predict caries-risk status with a high degree of reliability has been shown. Dentists, without using specific criteria, are reasonably able to predict caries risk in specific children without time- or money-consuming methods.[38,39] The ability of hygienists and nondentist health professionals to accurately predict caries risk also is documented.[40]

Microbiological testing

The use of microbiologic screening methods to assess caries risk has shown promise in human studies. As previously discussed, knowing the age when a child becomes colonized with cariogenic flora is important in determining risk. Additionally, the quantity of MS in a child's oral cavity is a risk indicator. Salivary MS counts, as determined by simple microbiologic testing in dentist's offices, have been reported to have a good specificity (ability to correctly identify those who will not get the disease) but less sensitivity (ability to correctly identify those who will get the disease).[41] In general, children who are highly infected with MS have a higher caries prevalence and a higher caries rate than children with low MS levels.[42,43] Currently, microbiological tests are not extensively used in private practices, perhaps due to cost, availability, and need to educate the profession regarding its value.

Socioeconomic status

There is consistent evidence to support a strong association between sociodemographic factors including income, and caries prevalence. Preschool children from low-income families are more likely to have caries.[3,44,45] However, as shown in Table 1, children from higher income levels may have less caries experience, but when they get the disease, their level of caries is similar to that of children of low income levels. Therefore, the socioeconomic condition in which a child is raised is an important caries-risk determinant, but does not predict disease on an individual basis.

Caries risk and anticipatory guidance

An understanding of a child's caries risk and the natural history of caries progression are important guides to parents and practitioners with regard to preventive and diagnostic schedules. By understanding caries risk for an individual child, future disease can be predicted and individualized preventive therapies initiated (Table 3).

Besides understanding the risk for new lesions in a child, caries-susceptible tooth surfaces can be anticipated in relation to the child's development and risk. Teeth exposed the longest to a cariogenic environment will be the first to show signs of disease. Thus, a child at high risk for early childhood caries may develop lesions on his or her maxillary anterior teeth soon after these teeth erupt. If the child continues to be at high risk, lesions may develop on the fissures of the primary molars and later on molar proximal surfaces.[46,47] Children with moderate caries risk develop caries at a later age—normally fissure caries on the primary molars without forming lesions on the incisors.[48,49]

Caries preventive strategies for preschool children

Education

The customary preventive dentistry program for preschool children often involves education of the parent regarding ways to prevent dental caries. These educational messages may attempt to persuade parents to stop putting their children to bed with a bottle, to reduce the child's high-frequency sugar consumption, or to convince parents to brush their children's teeth on a daily basis. However, outcomes suggest that educational programs improve knowledge, but only have a temporary effect on plaque levels, and have no discernible effect on caries experience.[50] Despite these limitations, oral health education will undoubtedly remain an important component of preventive dental programs. Efforts designed to improve the ability of educational messages to alter oral health behavior need to be pursued.

Diet

Fruit juices and fruit-flavored drinks have a substantial cariogenic potential because of their high sugar content and the way they are generally consumed. They are often used as a pacifying drink, and often are a mainstay of a preschool child's diet because of their high acceptance by children, low cost, and the belief by parents that they are nutritious. Because these drinks are frequently given to preschool children as continuous snacks often in bottles and sippy cups and/or given to children in bed, they are a constant source of sugar, and, consequently, create a great risk for caries. In addition to the problems of high cariogenicity of fruit drinks, there are reports of general health concerns about their excessive juice consumption by preschoolers.[51]

Milk also has been implicated as a cariogenic drink, but the sugar found in milk—lactose—is not fermented to the same degree as other sugars. Additionally, it may be less cariogenic because the phosphoproteins in milk inhibit enamel dissolution[52,53] and the antibacterial factors in milk may interfere with the oral microbial flora.[54] Human breast milk also has been shown to not cause enamel decalcification in laboratory experiments.[55] While the reduced cariogenicity of milk is clear, it may be the vehicle for more cariogenic substances. Parents should avoid combining milk or milk formulas with other food products or sugar.[56] Additionally, those infant formulas that contain sucrose instead of lactose may be particularly cariogenic.

Feeding practices in preschool children, especially inappropriate bottle feeding, have been implicated as the principal cause of caries in infants and toddlers. Yet, recent literature reviews suggest that the use of the baby bottle is not the only factor, and may not be the most important factor in caries development.[57] Another controversial dietary risk is the implicated cariogenicity of prolonged or nighttime breast-feeding, with several case reports associating breast-feeding with early childhood caries.[58-60] However, one cannot dismiss a possible association between reported rampant caries in these cases and other cariogenic dietary practices, such as lack of restriction in obtaining snacks that could contribute to caries in breast-fed children as well as in bottle-fed children.[61] However, despite these findings, it is still appropriate to discourage prolonged feedings with any sugar-containing foods.

Tooth-brushing

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.[62-64] However, there is convincing evidence for the decay-preventing benefit of tooth-brushing when used with a fluoride-containing toothpaste.[50] Three recent publications have shown that daily

Table 3. Caries-risk Indicators and Preventive Therapies Based on Risk*		
Caries-risk indicators		
Low risk	Moderate risk	High risk
Dfs<half the child's age	Dfs>half the child's age	Dfs>child's age
No new lesions in 1 year	1 or more lesions in 1 year	2 or more lesions in 1 year
No white spot lesions	Infrequent white spot lesions	Numerous white spot lesions
No enamel defects	Enamel defects	Enamel defects
Low titers of mutans streptococci	Moderate titers of mutans streptococci	High titers of mutans streptococci
High SES†	Middle SES	Low SES
	Visible plaque	Visible plaque
		Appliances in mouth
		Frequent sugar consumption
Preventive therapy		
Low risk	Moderate risk	High risk
Fluoridated dentifrice	Fluoridated dentifrice	Fluoridated dentifrice
	Systemic fluoride supplements	Systemic fluoride supplements
	Professional topical fluorides tx†	Professional topical fluoride tx‡
	Sealants	Sealants
	antimicrobials	Home fluoride/
		Dietary counseling

*Adapted from NIH Consensus Development Conference on the Diagnosis and Management of Dental Caries. *J Dent Ed*. 2001;65:1133-1142.
†SES=socioeconomic setting
‡Age and water supply considerations

tooth-brushing with fluoride toothpaste in 3 to 6 year olds significantly reduces caries incidence.[65-67] To prevent fluorosis from excessive swallowing of toothpaste children's brushing should be supervised with dispensing only a "pea-sized" amount[27] or dispensing the toothpaste in a transverse relation to the bristles.[68]

Having greater contact with fluoride toothpaste during brushing may have advantages. A modified brushing technique consisting of spreading toothpaste evenly on the teeth, brushing for 2 minutes, and reducing the rinsing of the mouth has been found to reduce caries by an average of 26% compared to a control group that also brushed with a fluoride toothpaste but received no instructions restricting rinsing.[69] Other studies have confirmed that rinsing after brushing with fluoride toothpaste should be kept to a minimum or eliminated altogether to maximize the beneficial effect of the fluoride contained in the toothpaste.[69-71]

Systemic fluoride supplements

If the fluoride content of the child's drinking water is unknown, a sample of the water should be analyzed for fluoride content, and, subsequently, systemic fluoride supplementation can be recommended considering the fluoride content of the water, the child's age, and the child's caries risk. Data from over 20 clinical trials show a caries reduction of 30%-80% in primary teeth from fluoride supplements, provided they are started close to birth and continued for 5 or more years.[72-76] However, there also is a growing body of literature showing that children, whether living in a fluoridated or nonfluoridated area, ingest sufficient quantities of fluoride from dentifrice, beverages, and foods,[77] and there is a strong association of dental fluorosis in the permanent teeth with fluoride supplement use.[50,78] Therefore, recent recommendations suggest that fluoride supplements should be prescribed only to children residing in nonfluoridated communities, who are identified as being at moderate or high caries risk.[27,28]

In addition to the use of fluoride supplements by children after 6 months of age, another suggested use has been to prescribe supplements to pregnant women with the goal of imparting caries resistance to the unborn child. Although fluoride crosses the placenta, prescribing fluoride supplements to pregnant women is not recommended because there is little evidence that fluoride provided to the mother during pregnancy reduces caries prevalence in their offspring.[79]

Professional topical fluorides

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. Although fluoride varnish has been widely used in Europe for more than 30 years, it was not introduced into the United States until 1991. At present, fluoride varnishes are approved in the United States as a cavity liner, but are used "off label" as a topical fluoride treatment. Their efficacy to reduce caries in primary teeth has been shown in several studies.[80-83] A recent study reported the results of children with early childhood caries who were treated with 5% NaF varnish every 3 months. After 18 months, those children treated with varnish had half the number of new carious surfaces on the maxillary anterior teeth and one third more arrested caries than a comparable control group.[84]

Antimicrobials

Some antimicrobial agents (chlorhexidine, iodine, and stannous fluoride) have been shown to be effective in suppressing MS, and, consequently, dental caries. In one study, high-caries-risk children who wore chlorhexidine-filled mouth guards to bed for 7 nights had significant reduction in MS levels for up to 3 months.[85] Another study showed a 38% reduction in approximal caries in children receiving 1% chlorhexidine gel treatments 4 times a year for 3 years compared to a control group.[86] Most interesting for the prevention of early childhood caries is a study in which mothers with high MS levels were given chlorhexidine gel by mouth guard for 5 minutes a day over 2 weeks. Their children showed delayed colonization of MS[87] and fewer caries than children in a control group.[88] However, additional studies need to be performed before an antimicrobial approach to treat caries in preschool children can be widely adopted.

Sealants

A multitude of clinical trials during the past several decades have shown that dental sealants are safe and highly effective in preventing pit and fissure caries (for review, see reference 89). Despite their effectiveness, however, sealant utilization has remained low in preschool children because practitioners are not convinced of its efficacy in primary teeth, difficulties placing them in preschool children, and sealant placement in primary teeth is not a reimbursable expense in most dental insurance plans, including Medicaid.

While most published data on the effectiveness of sealants refer to their use on permanent teeth, sealants on primary teeth also have shown value,[90-93] and 2 reports show effectiveness when placed in 3 to 4 year olds.[94,95] Furthermore, there is sufficient need to seal primary molars, as demonstrated in a Head Start report that found that, for those children who had dental caries, 86% had caries of the pits and fissures of the molars.[96]

Conclusions

Although dental caries in preschool children is highly prevalent in the US, there has been little national recognition of the issue, and little effort expended regarding its understanding, prevention, and treatment. Additionally, there is a lack of dental practitioners who are willing to see preschool children in their practices. Health professionals can be better prepared to address dental caries in preschool children by understanding its etiology, as well as identifying those children that are at risk. Not only will risk assessment identify children needing preventive services, but it will help direct preventive services to those children in the greatest need. Better utilization of caries-risk assessment and preventive strategies could produce enormous health benefits to preschool children.

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