Historical Evolution of Primary Dentition Caries Pattern Definitions

Walter J. Psoter, DDS, PhD   Douglas E. Morse, DDS, PhD   David G. Pendrys, DDS, PhD
Heping Zhang, PhD   Susan T. Mayne, PhD

*Drs. Psoter and Morse are assistant professors, New York University College of Dentistry,
Department of Epidemiology and Health Promotion, New York, NY; Dr. Psoter is associate professor, School of Dentistry, University of Puerto
Rico, San Juan, Puerto Rico; Dr. Pendrys is associate professor, University of Connecticut Health Center, School of Dental Medicine, Department of Behavioral Sciences and Community Health, Farmington, Conn; Dr. Zhang is professor, Yale University, School of Medicine, Department of Epidemiology and Public Health, Division of Biostatistics; Dr. Mayne is associate professor, Yale University, School of Medicine, Department of Epidemiology and Public Health, Division of Chronic Disease Epidemiology, New Haven, Conn.
Correspond with Dr. Psoter at wp9@nyu.edu*

Abstract

A variety of dental caries patterns encompassing differing teeth have been proposed, and their use may have utility in Early Childhood Caries (ECC) investigations by minimizing case misclassification. Recent reports have proposed multiple pattern schemes. The purpose of this paper was to review the historical evolution of ECC patterns to assist the clinician and researcher in understanding the strengths and limitations of contemporary caries pattern definition(s). (*Pediatr Dent.* 2004;26:508-511)

KEYWORDS: CARIES, CARIES PATTERNS, PRIMARY DENTITION, EARLY CHILDHOOD CARIES

Patterns of primary dentition caries encompassing different teeth surfaces have been previously proposed,[1-10] and these patterns have been used, implicitly or explicitly, as case definitions in prevalence and analytic studies.[11,12] The underlying assumption in these studies is that disparate patterns are the result of different etiologic agents, host status or responses, or environmental conditions.[1,13] Since each risk factor may have an association with caries that may be temporally critical itself and/or in relation to other factors of the cariogenic process,[14] these relationships could potentially be reflected in specific dental caries patterns.[9] The validity and precision of risk factor estimates in relation to caries patterns are dependent on valid and reliable case definitions, which caries patterns may represent. Moreover, designing and targeting efficacious and cost-effective preventive therapies, whether for the individual patient or the population, is dependent on accurate risk factor assessment that may be determined through etiological studies using such valid case definitions.

The purpose of this paper was to review the literature regarding caries patterns in the primary dentition during early childhood by identifying all pertinent scientific reports of Early Childhood Caries (ECC) patterns. The goal is to describe the conceptual approaches that have been taken, and identify areas of agreement in ECC patterns suggested to date. Established caries patterns are a prerequisite to the study of ECC prevalence, morbidity, and risk factors, and support the establishment of "best practices" (ie, scientifically valid procedures and interventions that optimize health outcomes) to prevent and control this important early childhood disease.

Review of descriptions of caries patterns

In 1982, Rule characterized caries of the occlusal, posterior proximal, anterior proximal, facial, and lingual surfaces.[15] He stated that "each group of surfaces has either a particular pattern of recognition or a special significance for interpreting the severity of the disease", implying a hierarchal morbidity by tooth surface groupings (ie, patterns). Rule identified special situations that did not fit his preceding categories.

Beginning in 1984, Johnsen and associates published a series of reports regarding caries patterns of the primary dentition. The first report discussed tooth defect lesions of the pit and fissure surfaces and hypoplasia, as well as what was described as "habit-associated lesions," (ie, nursing caries and proximal molar lesions).[16] Johnsen proposed 2 types of nursing caries patterns: one involving maxillary anteriors and first molars, and a second type primarily involving the lingual surfaces of the mandibular molars.

Table 1. Literature Regarding Caries Patterns in the Primary Dentition			
Authors	Year	ECC patterns	Notes
Rule	1982	Occlusal (pit and fissure), posterior proximal, anterior proximal, facial/lingual (pit and fissure, and smooth surfaces), hypoplasia, rampant, nursing-bottle	Described for primary and permanent dentitions.
Johnsen	1984	Pit and fissure, hypoplasia, nursing caries (maxillary anterior pattern, and lingual mandibular molar pattern), proximal molar, rampant	
Johnsen et al	1984	Pit and fissure, hypoplasia, facial-lingual smooth surface (or proximal anterior), proximal molar, rampant	A "minimal" and an "extensive" classification for each category was included and category assignment was to one category.
Johnsen et al	1987	Pit and fissure, hypoplasia, facial-lingual smooth surface (or proximal anterior), proximal molar, facial-lingual+ proximal molar	Category assignment was to one category.
O'Sullivan, Tinanoff	1993	Maxillary anterior, posterior, maxillary anterior+posterior	Assignment was to one category only.
O'Sullivan, Tinanoff	1993	Maxillary anterior, pit and fissure, proximal molar, posterior smooth facial-lingual	Assignment was to multiple categories, if applicable.
Douglass et al	1994	Maxillary anterior, pit and fissure, proximal molar, posterior smooth facial-lingual	Prevalence, severity, and distribution measures were presented for comparing populations.
Veerkamp and Weerheijm	1995	Maxillary anteriors and first molars, dependent on age	Stages are associated with specific ages and are described by teeth involved and extent of lesions.
Douglass et al	2001	Maxillary anterior, maxillary anterior+pit and fissure, maxillary anterior+pit and fissure+proximal molar, pit and fissure, pit and fissure+proximal molar	Grouped onto pattern combinations.
Psoter et al	2003	Maxillary incisors, first molar occlusal, second molar pit and fissure, smooth surfaces (other than the maxillary incisors)	Assignment is to multiple categories, if applicable.

Additionally, a pattern of rampant caries was defined as caries involving most surfaces of the dentition and, notably, including the mandibular incisors.

This first paper in 1984 was followed the same year with an analytic study using caries patterns defined on an a priori basis.[1] The authors describe patterns, which they term "pit and fissure," "hypoplasia," "facial-lingual" (inclusive of anterior teeth), "proximal molar," and "rampant." Children were classified as having only one pattern, with the hierarchy of assignment being the order presented here. For example, a subject with pit and fissure caries as well as facial-lingual caries would be assigned to the facial-lingual category. The authors note that "the intuitive listing of categories by priority is probably the greatest weakness." In fact, while a purpose of that study was to classify caries patterns (and determine their prevalence), the arbitrary groupings and hierarchical assignment to a single grouping would seem to be a methodological limitation. The patterns exist because they were observed to exist, and a case having lesions matching that definition is assigned to that category regardless of other lesions (or patterns).

Subsequently, Johnsen et al altered their categorization of patterns slightly, by dropping rampant caries and adding a facial-lingual/molar proximal pattern.[2] Using these pre-defined patterns, a cross-sectional study was conducted that examined the changes observed in these categories as a proportion of all the caries patterns of the study's subjects (2-5 years old). Limitations noted were a small sample size and the cross-sectional nature of the study. This report suggests different distributions of the defined patterns at various ages; interpretation may be limited, however, by the hierarchical assignment to a single pattern. For example, Johnsen et al stated that children younger than 2 1/2 years of age are generally either caries free or have a facial-lingual pattern. They also stated, however, that children with the facial-lingual pattern are more likely to have molar occlusal caries than those without the facial-lingual pattern. This latter observation leads to the question as to whether there are several "facial-lingual" subcategories (ie, those with and those without molar occlusal surface involvement).

The potential complexity of patterns within patterns finds support in a 1993 report.[3] Johnsen et al, using cluster analysis, demonstrated that a priori classifications tended to match the case clusters formed in his tooth surface-specific analysis, suggesting an analytic basis for the existence of these patterns. A number of smaller clusters, however, were less explainable by the classification scheme. As the authors stated, these clusters may represent a combination of patterns or unrecognized patterns.

A series of studies by O'Sullivan, Tinanoff, Douglass, and their associates supported and developed the concept of primary dentition caries patterns and expanded on the work of Johnsen and his associates. A 1993 report using 3 defined caries patterns of maxillary anterior teeth only, posterior teeth only, and maxillary anterior and posterior dentition caries, found differing levels of mutans streptococci across the defined caries patterns.[13] Based upon these findings, the authors concluded that different etiologies or the timing or duration of etiologic exposures may lead to different patterns or pattern combinations of caries. The implication of this conclusion is that analytic studies of risk factors would benefit by specific case definitions of those patterns. A second 1993 paper by O'Sullivan and Tinanoff demonstrated that, while children with and without maxillary anterior caries had similar percentages of pit and fissure caries, a significant difference was noted between the groups in terms of molar proximal as well as molar facial and lingual caries.[5] These findings suggest different morbidity levels associated with various caries patterns.

The results of these studies suggest the utility of an alternative to the one-subject/one-case definition approach. A limited number of patterns may be described, and any individual may, in fact, have none, one, or several of these caries patterns. Using this approach, Douglass et al presented a caries analysis system using 4 patterns.[7] The patterns were defined as caries of: (1) maxillary anterior surfaces; (2) pit and fissure surfaces; (3) molar proximal surfaces; and (4) other posterior smooth surfaces. In contrast to all but one earlier report, Douglass et al allowed an individual to have more than one pattern.[5] Of note, in this study different distributions of caries by pattern were observed for white, African American, Hispanic, and Chinese children. O'Sullivan and Tinanoff used the patterns of Douglass et al[6] in a 1996 report on a longitudinal-based study. The findings of this report suggest that the evolution of incident carious surfaces depends on the specific prior caries pattern. These findings may be considered evidence supporting the existence of caries patterns, or possible subpatterns, as well as a time dependency for manifestations of the various patterns and a possible lack of independence between patterns. In particular, the latter 2 studies[5,6] suggest that analytic investigations may be enhanced by improved pattern discrimination.

In 1995, Veerkamp and Weerheijm proposed a developmental approach to caries patterns.[9] These authors hypothesized that ECC associated with some nursing (feeding) behaviors results in caries patterns that are also a function of the child's dental development. The authors defined the patterns as stages that occur in overlapping time periods: (1) initial (ages 10-20 months); (2) damaged (ages 16-24 months); (3) deep lesions (ages 20-36 months); and (4) traumatic (ages 30-48 months). Each stage has a defined clinical appearance regarding the extent of caries and specific teeth involved. Essentially, a hierarchy of tooth destruction and tooth involvement is described and related to eruption patterns and risk factor exposures. This developmental approach emphasizes the importance of time as a determinant factor in caries patterns of the primary dentition.

The age/eruption-associated evolution of morbidity for "nursing caries" has provided qualified definitions for caries at various ages, and may be considered an elaboration of an earlier discussion of this condition in terms of tooth eruption.[17] Douglass et al reported on the relationship between 3 proposed caries patterns and eruption distributions and found support for eruption timing as an important determinant in caries pattern development.[8]

In general, the aforementioned studies have all used priori pattern definitions, substantiating the proposed patterns by differences across populations or risk factor distributions (with the exception of Veerkamp and Weerheijm's[9] proposed patterns). Notably, only 2 studies have analytically classified potential caries patterns. Johnsen et al subjected cases to a single-cluster technique and compared the resulting cluster memberships to previously assigned a priori-defined pattern membership of the subjects.[3] More recently, multidimensional scaling, a classification/taxonomy analysis of data, was employed without the use of predefined pattern definitions. That analysis identified 4 ECC patterns: (1) maxillary incisor; (2) first molar occlusal; (3) second molar pit and fissure (occlusal, mandibular facial pit, maxillary lingual fissure); and (4) smooth surfaces other than the maxillary incisors.[10] The delineation of separate first and second molar patterns supports the relevance of tooth eruption age in pattern determination. Table 1 summarizes the historical literature regarding caries patterns in the primary dentition.

Discussion

Proposed caries patterns differ in terms of the surfaces composing the patterns and whether or not a child can be assigned to more than one pattern. A common theme, however, emerges regarding the hypothesized caries patterns. In other words, patterns of maxillary anteriors, molar pits and fissures, and posterior proximal and other smooth surfaces are all suggested, either singly or in some combination. These caries patterns have been implicitly utilized in the current American Academy of Pediatric Dentistry (AAPD) Reference Manual 2003-04 definition of Early

Table 2. National Institute for Dental and Craniofacial Research's: Severe Early Childhood Caries Criteria

Age (ys)	Criteria
≤2	dmfs*>0 on any smooth surface†
3	dmfs=4 on any surface or maxillary anterior caries‡
4	dmfs=5 on any surface or maxillary anterior caries‡
5	dmfs=6 on any surface or maxillary anterior caries‡

*dmfs=decayed, missing, and filled surfaces.
†Caries of any smooth surface, regardless of dmfs score.
‡dmfs>1 on any anterior surface.

Childhood Caries,[18] which is based on an earlier report by Drury et al.[19]

In 1999, Drury et al reported on a proposed ECC case definition derived during a workshop on ECC. The proposed case definition of ECC defines 2 categories (Table 2) of caries in preschool children (ages<6 years old):

1. ECC, defined as any primary dentition caries;
2. severe ECC.[19]

The criteria for the severe-ECC category are stratified by age and described for each year of life (0-6 years old). These criteria are:

1. any smooth surface lesions in children less than 36 months old;
2. for 36- to 71-month-old children, any maxillary anterior lesions or dmfs (decayed, missing, and filled surfaces) scores of 4, 5, and 6 for children ages 3, 4, and 5 years, respectively.

The ECC case definitions reported by Drury et al have integrated age, morbidity, and 2 caries patterns (smooth surface and maxillary incisor caries). The workshop further recommended that research continue on the question of caries patterns in early childhood—hence, the importance of understanding the literature on caries patterns.

There is a clear but limited body of literature regarding the use of caries patterns as case definitions. Inconsistencies in the various proposed caries patterns, however, as well as the use of a priori-defined patterns imply that accurate ECC case definitions are yet to be validated. Furthermore, only 2 investigations have used analytic techniques that specifically allow the analysis to identify underlying patterns of the data. Additional research on defining such caries patterns is necessary.

If real, caries patterns should help reduce disease misclassification and, therefore, enhance the ability of an analysis to identify meaningful associations between suspected risk factors and ECC. Success in estimating accurate and precise risk factor determination will:

1. suggest appropriate public health and clinical practices to define high-risk populations/individuals and preventive interventions;
2. will assist in the establishment of "best practices" (ie, scientifically valid procedures and interventions that optimize health outcomes).

Enhanced preventive approaches at the clinical and population health service levels will minimize the number of children experiencing this chronic-infectious disease of childhood, which is endemic in some populations, particularly those populations experiencing social and economic disparities.

References

1. Johnsen D, Schultz D, Schubot D, Easley M. Caries patterns in head start children in a fluoridated community. *J Public Health Dent*. 1984;44:61-66.
2. Johnsen D, Schechner T, Gerstenmaier J. Proportional changes in caries patterns from early to late primary dentition. *J Public Health Dent*. 1987;47:5-9.
3. Johnsen D, Schubot D, Bhat M. Caries pattern identification in primary dentition: A comparison of clinician assignment and clinical analysis groupings. *Pediatr Dent*. 1993;6:113-115.
4. Greenwell AL, Johnson D, DiSantis TA, Gerstenmaier J, Limbert N. Longitudinal evaluation of caries patterns from the primary to the mixed dentition. *Pediatr Dent*. 1990;12:278-282.
5. O'Sullivan DM, Tinanoff N. Maxillary anterior caries associated with increased caries risk in other primary teeth. *J Dent Res*. 1993;72:1577-1580.
6. O'Sullivan DM, Tinanoff N. The association of early dental caries patterns with caries incidence in preschool children. *J Public Health Dent*. 1996;56:81-83.
7. Douglass JM, Zhang WY, Tinanoff N. Dental caries in preschool Beijing and Connecticut children as described by a new caries analysis system. *Community Dent Oral Epidemiol*. 1994;22:94-99.
8. Douglass JM, Tinanoff N, Tang JMW, Altman DS. Dental caries patterns and oral health behaviors in Arizona infants and toddlers. *Community Dent Oral Epidemiol*. 2001;29:14-22.
9. Veerkamp JSJ, Weerheijm KL. Nursing-bottle caries: The importance of a developmental perspective. *J Dent Child*. 1995;62:381-386.
10. Psoter WJ, Zhang H, Pendrys DG, Morse DE, Mayne ST. Classification of dental caries patterns in the primary dentition: A multidimensional scaling analysis. *Community Dent Oral Epidemiol*. 2003;31:231-238.
11. Resine S, Douglass JM. Psychosocial and behavioral issues in Early Childhood Caries. *Community Dent Oral Epidemiol*. 1998;26:32-44.
12. Ismail A, Sohn W. A systematic review of clinical diagnostic criteria of Early Childhood Caries. *J Public Health Dent*. 1999;59:171-191.
13. O'Sullivan DM, Tinanoff N. Social and biological factors contribution to caries of the maxillary anterior teeth. *Pediatr Dent*. 1993;15:41-44.
14. Seow W. Biological mechanisms of Early Childhood Caries. *Community Dent Oral Epidemiol*. 1998;26:8-27.
15. Rule J. Recognition of dental caries. *Pediatr Clin North Am*. 1982;29:439-456.
16. Johnsen D. Dental caries patterns in preschool children. *Dent Clin North Am*. 1984;28:3-20.
17. Ripa L. Nursing caries: A comprehensive review. *Pediatr Dent*. 1988;10:268-282.
18. American Academy of Pediatric Dentistry. Definition of Early Childhood Caries (ECC). Reference Manual 2003-04. *Pediatr Dent*. 2003;24:9.
19. Drury TF, Horowitz AM, Ismail AI, Maertens MP, Selwitz RH. Diagnosing and reporting Early Childhood Caries for research purposes. *J Public Health Dent*. 1999; 9:192-200.