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Beyond the dmft

The human and economic cost of early childhood caries

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ABSTRACT

Background. Early childhood caries (ECC) is the most common disease of childhood and often is accompanied by serious comorbidities affecting children, their families, the community and the health care system. This report describes morbidity and mortality associated with ECC and its treatment.

Methods. The authors reviewed the literature for descriptions and quantification of morbidity associated with ECC and organized a wide range of studies into a visual model—the morbidity and mortality pyramid—that begins to convey the breadth and depth of ECC's penetration.

Results. ECC exacts a toll on children, affecting their development, school performance and behavior, and on families and society as well. In extreme cases, ECC and its treatment can lead to serious disability and even death. In finding access to care and managing chronic pain and its consequences, families experience stress and, thus, a diminished quality of life. Communities devote resources to prevention and management of the condition. The health care system is confronted with management of the extreme consequences of ECC in hospital emergency departments and operating rooms.

Conclusions. Traditional epidemiologic measures such as the decayed-missing-filled teeth (dmft) index do not adequately portray the effects of ECC on children, families, society and the health care system.

Clinical Implications. The impact of prevention and management of ECC requires the attention of health care professionals and decision makers and extends well beyond the dental office to regulatory and child advocacy agencies as well as public health officials and legislators.

Key Words. Dental caries; quality of life; pediatric dentistry; caries susceptibility.

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The death of 12-year-old Deamonte Driver in 2007 as a result of untreated dental caries[1] gave lack of access to dental care a new and disturbing face for many Americans—that is, the potential for serious morbidity and even death resulting from dental caries. Behind the headlines and outrage surrounding that watershed event exists a shadow world of suffering, pain, diminished quality of life, and even death known to but a few on the front lines of the early childhood caries (ECC) epidemic. The educated, insured and employed, including many in the dental profession, have been shielded from the consequences of untreated ECC experienced by hundreds of thousands of the 4.5 million children who develop the condition annually. Death and serious morbidity resulting from ECC and its treatment are not new or confined to one disseminated infection. Death—resulting from local anesthetic overdose, sedation or general anesthesia mishap and even choking[2]—has in fact happened in attempts to treat this most common of all chronic childhood diseases. While these

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extreme events tend to come before the public, the daily consequences of ECC to families, the community and society often go unnoticed.

Traditional surveillance measures for ECC fall short in conveying ECC's impact and in connecting it to the full range of consequences experienced by affected children and their families. Dental epidemiologic measures such as the decayed, missing and filled surfaces (dmfs) and decayed, missing and filled teeth (dmft) indexes do not imply the full scope of the disease's impact on children, families, society and the health care system. According to Jacques,[3] "The ultimate value of any classification system … will be determined by its ability to provide the user with information that will assist in understanding or solving clinical problems."

Similarly, utilization measures such as treatment visits fail to impart a robust picture of the effects of ECC. Service utilization is an imperfect surrogate for morbidity,[4] as the true impact of a disease often lies outside the realm of direct medical care delivery. While consequences of ECC—explored in this article—are far-ranging, supportive data often are dispersed, difficult to find or not collected at all. In this report, we review evidence from a variety of perspectives to argue that the consequences of symptomatic ECC are multiple and significant and that broader surveillance of the disease's impact is needed.

BEYOND THE BIOLOGICAL MODEL: A MORBIDITY PYRAMID

The presence of high levels of ECC, despite a reduction in permanent-dentition caries through fluoridation of water and use of fluoridated toothpastes, begs for a broader look at social and behavioral factors that correlate with this form of the disease. Fisher-Owens and colleagues[5] proposed a model for pediatric oral disease that superimposes child, family and community factors over the classic Keyes biological model to indicate the influence of these nonbiological factors on caries initiation (Figure 1). Various additional research efforts support a relationship between ECC and these behavioral, environmental and social factors.[6-10] Consistent with the "common determinants" approach to understanding disease occurrence in populations,[11] coincident morbidities are common in ECC.[12,13]

A traditional method of describing disease impact is a morbidity and mortality (M&M) pyramid, in which increasingly severe consequences are stacked one on another.[14] ECC, with its low rate of associated fatality and high rate of dysfunction, takes on the classical shape, with a broad base and narrow apex (shown in Figure 2 [page 653] as Type A).[15] A disease with a high degree of fatality, such as pancreatic cancer with its low five-year survival rate, may appear as an inverted pyramid[16] (Type C), while one with an intermediate degree of fatality appears more as a rectangle[17] (Type B). The M&M pyramid classification system provides a valuable means of quantifying disease impact through consequences ranging from mild dysfunction to death.

An M&M pyramid allows one to both observe a meaningful measure of consequence and relate that measure to other consequences. For example, for every death resulting from ECC or its treatment, one expects a certain number of hospital admissions, missed school days or episodes of pain-induced difficulty in eating or sleeping. Use of M&M pyramids can help clinicians relate the occurrence of comorbidities and, through intersecting tiers, identify groups at higher risk of experiencing illness or adverse effects.[18] The study of M&M pyramids can highlight the magnitude of a disease's effect on society and its components.[19] Through the examination of a disease's impact, health care professionals can better direct resource allocation and utilization of services to maximize prevention and treatment.[20] An M&M pyramid can represent dimensions of a disease in a range of patients, from those who are at low risk to those who experience the worst outcomes; therefore, it can provide insight into associated expenditures and loss of human capital.[21,22]

Figure 3 (page 654) depicts a draft ECC M&M pyramid. Whereas clinicians know well that the impact of ECC involves many tiers, supportive data are insufficient to fully quantify these tiers. Some must be constructed with aggregate data, often without clarity or safeguards regarding accuracy. For example, an oft-cited statistic related to dental disease is the number of days of school attendance lost,[23] but this measure includes not only the days of school that children miss because of pain or dysfunction, but also elec-

ABBREVIATION KEY. CT: Computed tomography. **dmfs:** Decayed, missing and filled surfaces. **dmft:** Decayed, missing and filled teeth. **ECC:** Early childhood caries. **ED:** Emergency department. **M&M:** Morbidity and mortality.

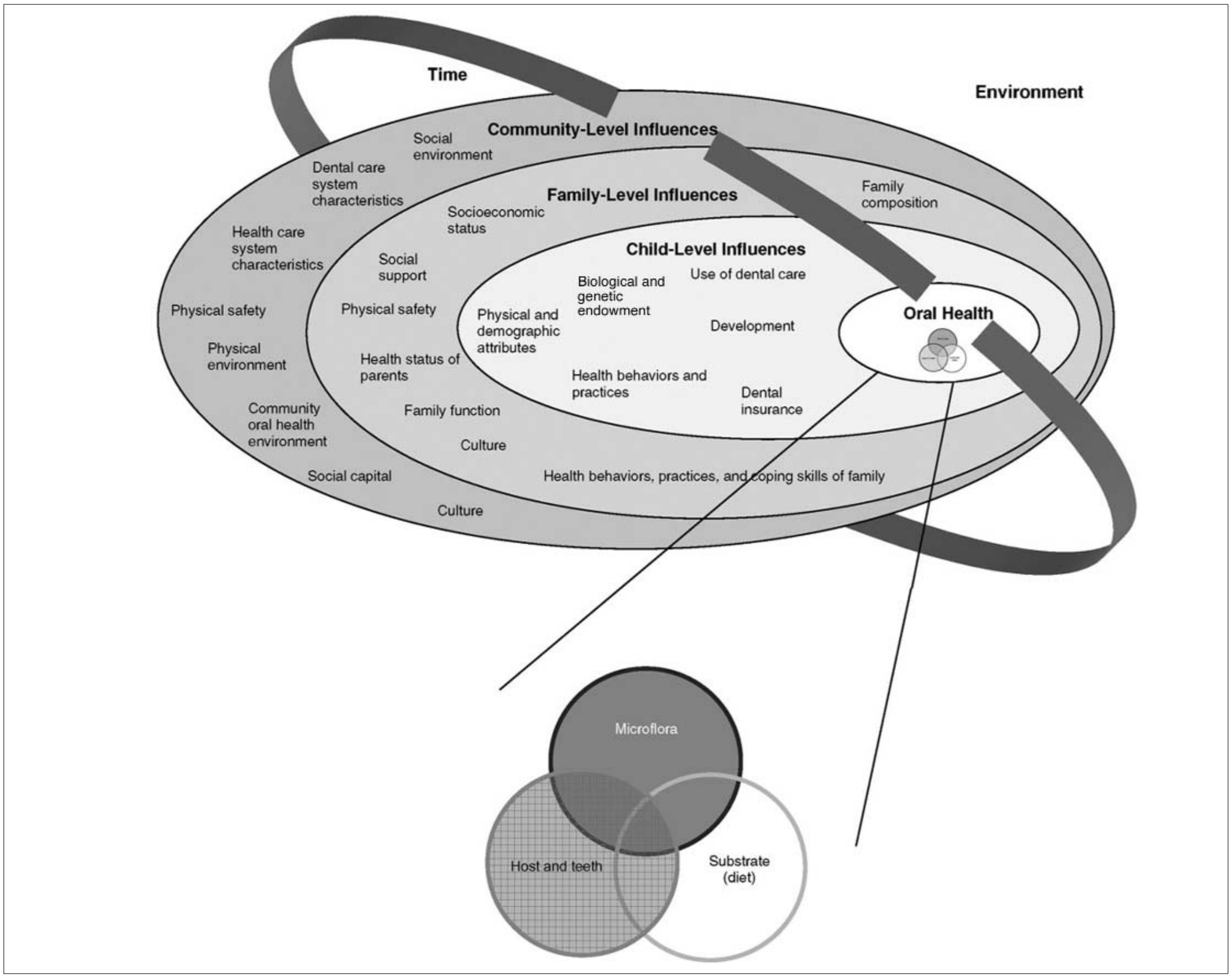

Figure 1. A multifactorial model of early childhood caries depicting possible roles for the child, the family and the community beyond the classical biological infectious disease model. Reprinted with permission of the publisher from Fisher-Owens and colleagues.[5]

tive time away from school for routine dental visits. Constructing pyramids also is hampered in part by multiple consequences. For example, there is overlap within tiers, such as the total cost of a hospitalization for a child with ECC, which might include the costs of emergency department (ED) care as well as charges for a multiday stay and for treatment in the operating room. These significant events, even if measured carefully, still may not indicate the human costs to families arising from disruption of life, work and school because of the difficulty encountered in quantifying secondary impacts.

Mortality associated with dental caries and dental intervention. The case of Deamonte Driver probably is the best-known case of caries-related mortality. Lesser known are the cases of Alexander Callender, a 6-year-old Mississippi boy who died of sepsis,[24] and Jackie Martinez, a 7-year-old California girl who choked on a crown during a dental visit.[2] Unknown to but a few involved in their care are the names of many other children who have died as a result of sedation mishaps or an overdose of local anesthetic during treatment for ECC. ECC-associated mortality secondary to infection and treatment likely never will be known owing to inadequate surveillance, lack of an ECC registry, issues of confidentiality, the terms of some legal settlements, missing or incorrect diagnoses, and even inconsistent diagnostic coding choices by hospitals and physicians. Among brain abscesses alone, 15 percent result from infections of unknown source, some or many of which may be of dental origin.[25] It is likely that mortality related to ECC and its treatment is underreported. Coté and colleagues,[26] in an attempt to identify pediatric deaths related to sedation during an almost 30-year period, commented that their study sample represented a gross underreporting while also stating that dental specialists were disproportionately represented among all pediatric health providers.

Hospital admissions, ED care and use of general anesthetics. In many hospitals' EDs, a leading pediatric admission symptom is dental pain. Families seek out ED dental care for a variety of reasons, including lack of a primary care dentist, inability to pay a dentist, a perception that their child is in serious danger or pain, and proximity or convenience.[27] ED dental intervention is, in most cases, limited to management of pain and infection, leaving the source untreated at significant cost to the patient, the hospital and society and impeding a system designed and staffed for emergent medical events.[28]

Many ED admissions become prolonged hospitalizations for management of facial cellulitis. The length of stay averages five days but can be far longer, and the cost of care can be significant.[29] Ettelbrick and colleagues[30] reported in 2000 that the average cost of care across five children's hospitals for a single admission for odontogenic infection was $3,223. As with ED management of ECC infection and pain, many such hospitalizations do not result in definitive care for either the offending tooth or other carious teeth. Worse, these interventions may have untoward consequences. In a recent study of pediatric patients with facial cellulitis, researchers found that ED physicians were more likely to order computed tomographic (CT) imaging than were pediatric dentists, with no difference in treatment outcome.[31] This finding is most relevant because a growing body of literature suggests that head and neck CT imaging is responsible for an increase in thyroid cancer incidence in children.[32,33]

Treatment under general anesthesia for extensive dental repair is another costly and potentially risky consequence of ECC. Tens of thousands of young children in the United States undergo restoration and extraction of teeth under general anesthesia annually. The absolute numbers are not known as, for example, dental office–based use of anesthetics may not be recorded and dental treatment performed in conjunction with physicians' surgical services may not be tracked for either medical or dental procedures in existing registries. Estimates available

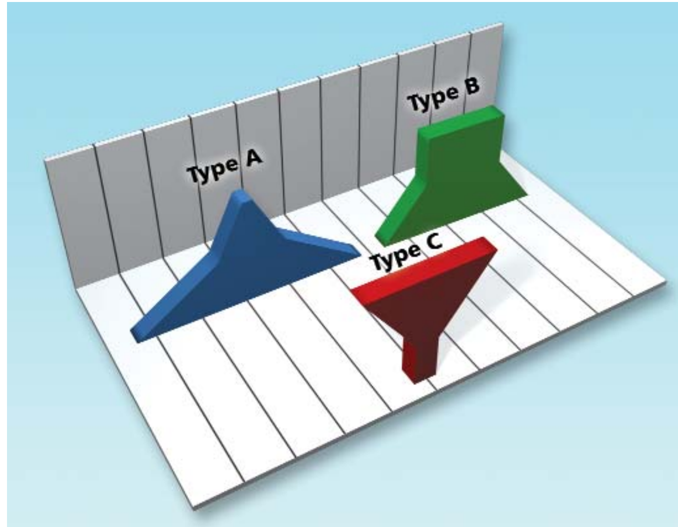

Figure 2. Examples of the morbidity and mortality pyramid, the shape of which is based on the characteristics of an individual disease entity. Reprinted with permission of the publisher from Wadman and colleagues.[15]

are based largely on records of Medicaid-insured children treated in hospitals. White and colleagues[34] reported that more than 5,500 children received general anesthetics for dental services in North Carolina alone across a two-year period. Griffin and colleagues[35] reported that more than 2,100 Medicaid-covered children received dental treatment under general anesthesia in Louisiana in a one-year period, with 60 percent of these children being 3 years or younger. The costs of these services to families and the public are significant, with mean costs in this one study calculated at $1,508 per admission.[35] Extrapolating these costs across tens of thousands of children who receive general anesthetic services annually in the United States exposes an expenditure of millions of dollars for treatment of a largely preventable disease. The human toll of treating children under general anesthesia also can be significant. Cravero and colleagues[36] included dental cases in their assessment of adverse events in sedation and general anesthesia, stating that of all patients who receive these services, the pediatric population is at highest risk and has the lowest tolerance for error.

ECC, child development and well-being. Parents of children seeking emergency dental care reported that 19 percent of the children experienced interference with play, 32 percent with school, 50 percent with sleeping and 86 percent with eating.[37] As early as 1992, Acs and colleagues[38] reported a relationship between ECC

Figure 3. A proposed early childhood caries morbidity and mortality pyramid.

and failure to thrive—a condition of poor growth in young children—in a cohort of low-income children. Body measurements and blood test results indicative of malnourishment are significantly associated with severe ECC and suggest iron-deficiency anemia.[39] These reports and others stimulated interest in the effects of ECC and its treatment on child growth, looking at factors such as dysfunctions in eating, sleeping, mood and attention. Knowledge of the impact of ECC on the development of the child in physical, emotional and intellectual terms is fragmented. Episodic pain from dental caries is well-established as a constant finding, even from an early age, affecting up to 20 percent of preschoolers.[37,39-41]

The effect of ECC-related pain on distraction from learning and school performance, while not generally measured, is significant. One cross-sectional study reported that more than one in 10 schoolchildren experienced tooth pain,[42] and another identified an association between poor systemic and oral health and poor school performance.[43,44] Anecdotally, school systems nationwide, particularly those that serve a significant low-income population, report that dental problems contribute to learning difficulties. School nurses act as dental case managers on a daily basis.[45] A study in Michigan has documented loss of sleep, inability to concentrate in school and absences from school all caused by dental caries–related pain.[46]

When the federal government last surveyed the impact of caries on the activity of children in 1996, a rough estimate of 9.3 percent of U.S. children younger than 5 years experienced "restricted activity days," and an additional estimated 3.7 percent of these preschoolers incurred "bed days" because of dental problems.[47] The study noted disparities by income and race that correlate closely with disparities in disease experience among subpopulations of children in the United States.

A growing concern in pediatric emergency medical care is acetaminophen toxicity caused by excessive administration of the drug by parents for management of pain.[48] Toxic doses of the medication can accumulate rapidly, causing liver damage in small children.[49] The use of acetaminophen for management of ECC-related pain is common, but its extent and effect remain unknown.

Consequences of oral infection for systemic health have been explored more completely in adults with regard to periodontal infections than in children with regard to odontogenic infections secondary to ECC. The biological rationale for oral-systemic associations, however, may have strong utility for anticipating the effect of chronic odontogenic infections on children's overall well-being. Little has been studied about the effect of chronic pulpal infection, bacteremia and circulating inflammatory proteins on a young, healthy child's function, growth and development, healing and disturbances in development of pain perception.[50] Similarly, little is yet known about the potential ECC-driven exacerbation of chronic pediatric diseases among children affected by such conditions as asthma and diabetes. Some research supports a role for ECC in both physical and emotional health, as ECC treatment ameliorates many ECC-related dysfunctions. For example, dental treatment of teeth with ECC results in pain elimination and has been associated with improved growth velocities[51] and improved quality of life.[52-54]

The effects of ECC on family, community and health care systems. ***Family.*** At the level of family consequences, there is a troubling association between ECC and child maltreatment. Sheller and colleagues[55] concluded that a dysfunctional family or social situation can lead to a recurrence of ECC, often with emotional outbursts and the threat of or actual violence. The relationship between ECC and neglect is well-established, but only recently have child maltreatment experts included dental caries in their listing of health conditions that predispose children to maltreatment.[56,57]

Community. The impact of ECC on communities is beginning to be realized. State officials have begun to recognize that citizens are concerned about dental caries and access to care.[58,59] Care of children with ECC consumes a disproportionate share of dental expenditures because of the typical extent of disease and concomitant costs of treatment under general anesthesia in the operating room. Recently adopted policies to address ECC (such as that of the American Academy of Pediatric Dentistry's Clinical Affairs Committee[59]) will bring children into dental offices far earlier in an attempt to prevent dental caries, but they will require an increase in or diversion of workforce and health expenditures. Whereas early interventions to prevent and manage ECC have been modeled as both cost effective[60] and cost saving,[61] authors from the Centers for Disease Control and Prevention[62] reported in 2005 that under current dental system capacity constraints, widespread implementation of early intervention may crowd out existing reparative care that is being provided to children with ECC.

Health care systems. ECC's impact on health care systems may well be significant. Some have proposed significant changes in dental insurance coverage to reduce care for low-risk children and expand care for high-risk children.[63] Others propose reorganization of the dental workforce, either via creating an intermediate-level therapist capable of providing disease management, restorative care or both to affected children[64] or via expanding the engagement of medical providers.[62] Both of these approaches will affect costs associated with reconfiguring the educational infrastructure, shifting practice patterns of the existing workforce and addressing the behavioral aspects of ECC management.

ECC has a tremendous, but often invisible, impact on society and the health care system. Recognition of its pervasiveness likely will drive oral health planning for the foreseeable future.

Growing evidence gathered with epidemiologic instruments supports a diminished quality of life for families with children affected by ECC,[52-54] but the pressures families experience in a daily-life context are less clear. ECC is strongly associated with vulnerable subpopulations, including children of impoverished, minority, immigrant, migrant and homeless families whose social and economic capital is limited.[65] Loss of a job, loss of income for time spent taking a child to multiple dental appointments, the cost of transportation, taking time to find a willing dentist and financing care are real and significant issues for these families, exacerbated in today's chaotic economy.

The downward spiral of ECC has become an all-too-familiar cycle. Children develop ECC that advances to a painful level. Parents delay care because of finances and access-to-care problems, and the child's condition continues to worsen until it becomes so acute as to demand intervention regardless of the effect on the family's resources. Often, when these families finally gain access to care, they encounter significant delays, because the available treatment resources are far outstripped by the need and demand for them. Finally, the cycle is perpetuated as ECC predisposes children to future caries in primary and permanent teeth.[66-68]

SUMMARY

Surveillance measures such as the percentage of children affected by ECC or disease extent as measured by dmfs and dmft indexes need to be supplemented by objective measures of disease consequences ranging from dysfunction to death. Meaningful assessments of the effect of ECC on child development, learning and family function and the economic burdens it places on families, communities and the health care system are needed to describe the importance of this preventable disease adequately. Until such a comprehensive assessment—including routine diagnostic coding—is developed, the epidemic of ECC likely will continue to put the health and lives of children at risk, because few public and professional policymakers will consider ECC of sufficient importance to take meaningful action. Only when the picture of an affected child's life replaces a technical dental statistic will society act to redress the most common of childhood's illnesses. ■

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