Abstract

Dental caries and periodontal diseases are atypical infectious diseases with almost universal prevalence. Their shared etiology is disruption of homeostatic biofilms on the teeth. Risk for severity of these diseases varies considerably across individuals and subpopulations. Both diseases meet the criteria of chronic diseases by being longstanding, progressive, unresponsive to acute management, and consequential. Like other chronic diseases, the primary determinants of risk and experience are environmental and behavioral and therefore not responsive to acute-care clinical interventions. Traditional dental repair is effective at alleviating symptoms, restoring form and function, and providing esthetics but not at inhibiting disease progression. Despite extensive research and development of disease management approaches, the dental profession—with its surgical heritage, educational and business models, and independence from the larger healthcare systems—has not widely adopted a “chronic disease management” approach to care. Long needed are refined risk models, evidence-based preventive and suppressive protocols and care-paths, health information technology support for disease management and patient follow up, structural incentives in payment and organization, and staffing with oral health “coaches” who apply behavior change approaches derived from health education, social work, and behavioral nutrition. Pharmacological and behavioral interventions hold promise to augment current reparative modes of dental care with effective techniques that can facilitate patient self-management. Clinical, cross-boundary (between individual and public health interventions), research, and behavioral models derived from medicine each contribute concepts to a redesign of dental care that may improve outcomes and lower costs through individual control of disease progression.
Preface

The potential for expanding dental care to include non-surgical management of common dental pathologies has been well envisioned for both pediatric dental caries and adult periodontal disease:

For caries: “Current evidence regarding the carious process and caries risk assessment allows the practitioner to go beyond traditional surgical management of dental caries. Therapy should focus on patient-specific approaches that include disease monitoring and preventive therapies supplemented when necessary by restorative care. The type and intensity of these therapies should be determined utilizing clinical data as well as knowledge of the caries process for that child. Changes in the management of dental caries will require health organizations and dental schools to educate students, practitioners, and patients in evidence- and risk-based care.”

For periodontal disease: “Regular home care by the patient in addition to professional removal of sub-gingival plaque is generally very effective in controlling most inflammatory periodontal diseases. If clinical signs of disease activity persist, pharmaco-therapeutic therapies should be considered. Attention to detail, patient compliance, and proper selection of adjunctive antimicrobial agents for sustained plaque control are important elements in achieving successful long-term results. Frequent re-evaluation and careful monitoring allows the practitioner the opportunity to intervene early in the disease state to reverse or arrest the progression of periodontal disease with meticulous nonsurgical anti-infective therapy.”

Yet, with the exception of mechanical tooth cleaning (“dental prophylaxis”), US dentists persist in preferentially and primarily providing surgical (aka “reparative” or “restorative”) treatments that redress the signs and symptoms of common oral diseases rather than managing the underlying disease processes. Lacking in refinement are evidence-based and protocol-driven risk assessments, individualized counseling, pharmaco-behavioral modifications of risk factors, and longitudinal case management supported by health information technologies. As a result, preventable oral diseases are not prevented or controlled to the extent possible, population-level oral disease burden remains high, treatments frequently fail, and opportunities for better health at lower cost are lost. This situation stands in sharp contrast to the vision of oral health promotion detailed by the US Surgeon General in which “daily hygiene routines and healthy lifestyle behaviors” by individuals, “periodic professional diagnostic, preventive, and therapeutic services and counseling” by dental providers, and “school- and community-based oral health promotion and disease prevention activities” in communities combine to reduce disease occurrence.
This contribution to the Committee’s work describes opportunities for shifting dental treatment paradigms from primarily surgical to also more widely adopt medical interventions—including lessons learned from medicine’s approaches to chronic disease management, infectious disease management and bio-behavioral models. This paper considers common oral diseases in the contexts of chronic diseases; examines how dentistry has—and has not—adopted a chronic disease management approach to their treatment; explores reasons for widespread failure to adopt chronic management approaches; and suggests opportunities to promote change.

What is the nature of common oral diseases? What are the opportunities for their management?

The infectious caries process that leads to cavities is initiated early in life and occurs well before signs or symptoms are evident. It is virtually universal in the US as more than one-quarter of children under age six years (28%) have visible tooth decay experience increasing to 51% among six-11 year olds, 59% among adolescents, 86% among adults ages 20-34, and 96% among 50-64 year olds. Consistent with the characteristics of a chronic progressive disease, once initiated, caries also impacts growing numbers of teeth with age (figure). Despite a statistically significant downward temporal trend in the numbers of affected teeth, prevalence remains extreme. Notably, the occurrence of tooth decay is disproportionately concentrated in low-income and minority children, particularly Latinos and Native Americans. Even in childhood, the disease is consequential in morbidity and cost. Nine percent of children experience “restricted activity days” and 4% “bed days.” The disease continues to be
consequential into adulthood with one-in-ten adults missing work or school because of a dental problem, most typically related to caries.

The infectious periodontal disease process is more subtle and depends more upon host susceptibility since equivalent bacterial exposures result in widely divergent clinical presentations. In general, as oral hygiene has historically improved, mild inflammatory periodontal conditions have declined in prevalence while the prevalence of more severe and advanced presentations of the disease have remained fixed, reflecting underlying population levels of host susceptibility. The destructive nature of periodontal disease is measured by “loss of attachment” —the numbers of millimeters of ligament loss between tooth and bone—but case definitions vary widely. As a result, prevalence estimates for the US and other populations vary yet all confirm that the disease is prevalent and progressive among adults. NHANES reports rates of significant periodontal disease (defined as loss of at least four millimeters at one or more tooth sites) that increase from 2% of the population at ages 18-19 to 25% at ages 40-49, to 60% of the population above age 70. Periodontal disease, rather than caries, has long been the primary cause of tooth loss in the U.S. As tooth loss declines and greater numbers of older Americans retain their dentitions, caries (particularly root surface caries) and dentition maintenance become greater concerns.

Before considering opportunities to advance oral disease prevention and management, it is essential to define terms because the word “prevention” in dentistry has been inappropriately extended to include all non-surgical interventions. For purposes of this paper, the term “prevention” is used in its narrow sense of measures taken to avoid the onset of diseases rather than curing them or treating their symptoms. This work utilizes the Congressional Budget Offices’ (CBO) description of “disease management” as including “educating patients about their disease and how they can better manage it;” “actively monitoring patients’ clinical symptoms and treatment plans following evidence-based guidelines;” ”coordinating care for the disease among all providers;” and “providing feedback on individual patients and support to physicians about patients’ status between office visits as well as up-to-
date information on best practices for particular patients."¹⁴ Emphasizing the importance of patient self
management, “disease management” has been defined as “a system of coordinated health care
interventions and communications for populations with conditions in which patient self-care efforts are
significant.”¹⁵ Thus, this paper’s reference to disease management encompasses four key elements: (1)
redress of chronic conditions; (2) a systematic approach to care that informs, advises, and engages the
patient (or the at-risk population); (3) care in which the patient is actively engaged in self-management or
the population is actively engaged in disease control; and (4) care that results in reduced morbidity and
mortality and improved quality of life. The term “medical management” further defines “disease
management” to suggest that the interventions involved are pharmacological and/or behavioral rather than
surgical.

CBO offers the example of diabetes management (figure) to suggest that disease management
holds strong potential to increase adoption of evidence based care and improve health outcomes that
include quality of life, appropriate healthcare utilization, and economic improvements (figure).
Figure 1.

The Path by Which a Disease Management Program for Diabetes Could Lead to Better Health Outcomes and Lower Health Costs

**Disease Management Intervention**
- Selection of patients
- Education
- Communication
- Monitoring
- Feedback
- Coordination of care

**Process Outcomes**
Adherence to evidence-based guidelines, such as:
- Annual foot and eye exam
- Annual tests for kidney function and cholesterol
- Biannual test for hemoglobin A1c, or control of blood sugar

**Intermediate Outcomes**
Changes in intermediate measures, including:
- Hemoglobin A1c
- Blood pressure
- Cholesterol

**Health Outcomes**
Changes in the incidence of outcomes, including:
- Blindness
- Leg amputation
- Heart attack
- End-stage renal disease
- Death

**Quality of Life**
- Related to cost-effectiveness

**Health Care Utilization**
Changes in the utilization of services, including:
- Hospitalization
- Doctor visits
- Emergency dept visits
- Dialysis

**Economic Outcomes**
- Cost of the intervention minus any savings from health improvements

Source: Congressional Budget Office.
Biological basis for disease management in dentistry

Both caries and periodontal disease have been well characterized as “ecological catastrophes” in which poor health behaviors disrupt the balanced (“homeostatic”) relationships between our mouths and the bacteria that colonize them in health. In particular, our teeth are normally covered in biofilms to which complex microbial communities are attached in the form of dental plaque. The composition of this dental plaque is exquisitely sensitive to its environment. Environmental “pressures” that result from excessive exposure to sugar lead to tooth decay by shifting the bacterial composition of plaque from a “normal” to a “pathological” mix in which acid-producing (“acidogenic”) and acid tolerant (“aciduric”) organisms predominate. Similarly, leaving plaque undisturbed by failing to maintain adequate oral hygiene can result in ecological shifts that destroy the tooth’s attachment to the gums, particularly in people predisposed to severe periodontal disease.

Types of bacteria with certain traits, rather than specific bacteria per se, are therefore “pathogenic” for caries and periodontal disease even though they are normally present in small numbers under conditions of health. Unlike other bacterial pathologies in the human experience, disease results from “imbalance of indigenous oral biota” and not from the introduction of “exogenous pathogens.” That is, oral pathogens are not single organisms that colonize sterile tissues as, for example, does E. coli in urinary tract infections. Nor are they specific organisms that are normally not found in bacterial colonization of humans, like Salmonella in food poisoning or Helicobacter pylori in peptic ulcers. Instead, they are a constituent of normally acquired (typically from maternal-to-child transmission early in life) flora that run amok when external environmental influences cause them to predominate. In the case of caries, any bacteria that is both acidogenic and aciduric will dissolve (“demineralize”) the tooth surface faster than normal repair (“remineralization”) can occur with the assistance of saliva, particularly when fluoride is present. For periodontal disease, the primary external influence is plaque that is left undisturbed by failure to brush and floss. In sensitive people, this plaque instigates inflammation that becomes progressively more damaging, and ultimately fatal, to the attachment between tooth and gums.
In this conception, the mouth is a “microbial habitat” characterized by specialized tissues (teeth and gums) that provide a wide variety of distinct niches for bacterial colonization. This habitat is significantly influenced by exposure to air, saliva, food, fluoride, the tooth brush and dental floss, and when present also to smoke, tobacco, alcohol and other noxious agents. Treatments for diseases that result from “imbalances” and “perturbations” in plaque composition focus either on reducing or eliminating the plaque pathogens or, more commonly, on regulating the environment so that the shift from homeostatic to pathogenic plaque does not occur.

For caries, disease management strategies include delay of cariogenic flora transmission inhibition of acid production through use of topical fluorides including tooth pastes, rinses, gels, and varnishes; non-specific antimicrobial agents such as chlorhexidine (Peridex®) and Triclosan; reductions of sugar consumption or substitution of simple sugars by non-nutritive sweeteners that cannot be transformed by bacteria into acids (e.g. Xylitol); and physical plaque disruption. Highly beneficial is reducing the numbers of sugar exposures each day by eliminating the nocturnal bottle in young children or minimizing between-meal snacking in older children and adults. Also helpful is stimulating salivary flow, for example by chewing sugar-free gum or consuming a sugar-free sour lozenge. Thus, prevention and disease management depend on health awareness, oral health knowledge, and habitually positive oral health behaviors. In short, they depend upon self management rather than health-professional management, at least until cavities form that require repair in order to restore form and function.

For periodontal disease, management strategies focus on physical plaque removal and biofilm disruption. Secondary supportive approaches may include short term application of antibacterial, anti-inflammatory, or oxidizing agents. Here too, disease management depends upon self-management rather than professional care per se.

Unlike treatment for classical bacterial infections, neither a simple course of antibiotics nor supportive care that allows the body to mount a sufficient immunologic defense is effective in managing either caries or periodontal disease. Rather, the essential intervention is the establishment and long-term maintenance of a homeostatic interface between plaque and host. Such intervention can only be
accomplished through promotion and adoption of continuous salutary dietary and oral hygiene behaviors. Accordingly, Marsh observes that the “enlightened clinician will...take a more holistic approach and take into account nutrition, physiology, host defenses and general well-being of the patients, as these will affect the balance and activity of the resident oral microflora.” He distinguishes this “holistic” approach from current practice in which a dental clinician “faced with plaque-mediated disease treats only symptoms,” i.e. cavities and periodontal inflammation while failing “to identify the causal factors driving this local ecological catastrophe in plaque, and deal with both the cause the effect of the disease.” Among causes cited are “poor oral hygiene, an inappropriate diet, smoking and the long term use of medications that, as a side-effect, reduce the flow of saliva or suppress the activity of components of the adaptive host defenses.” Marsh envisions “future developments in oral care [that] will recognize these interrelationships [between plaque and host] and use multiple strategies to maintain homeostasis and hence a favorable ecology in plaque.”

Dental professionals are well educated in the pathobiology of caries and periodontal disease at the molecular, cellular, tissue and individual levels. They are familiar with the extensive animal model research from the 1950’s and 60’s that established the infectious and transmissible nature of dental caries\textsuperscript{20} and of periodontal disease\textsuperscript{21} and the more current research that apply those findings to humans.\textsuperscript{22,23} They appreciate the roles of diet and hygiene in plaque management and routinely share health promoting instruction with their patients—most often in a “one size fits all” prevention recommendation rather than a risk-tailed explicit pharmacological or behavioral intervention.

Dental educators and researchers have long called upon the profession to take up this more “holistic” approach to care. Over four decades ago (shortly after NIH had explicated the infectious nature of dental caries and periodontal disease), the New York Academy of Sciences convened a conference on “Dental Diseases and Therapy”\textsuperscript{24} that decried the surgical approach to care, noting its extreme costs and futility. The Conference called for “continuous improvement of the techniques available for the evaluation of preventive or control procedures.” Conference papers included a review of caries susceptibility tests that concluded with a statement that remains true today, “Until methods to measure
reliably and correlate each [risk factor], it is not likely that caries susceptibility tests will be sufficiently accurate to warrant widespread clinical or research use.” In short, the concepts of risk assessment and risk management have long been alive in dentistry but remain short of widespread adoption for reasons that remain unchanged since the 1968 conference. These include lack of validated risk models, inadequately or inappropriately trained dental workforce, failure to translate research into science-based or evidence-based care, lack of reimbursement for prevention and disease management, perceived or assumed patient reluctance to seek or accept disease management care, and the difficulties of instituting behavioral change at the individual level.

In 1980, 30 years before this year’s enactment of Health Reform, the Institute of Medicine’s prescient report, “Public Policy Options for Better Dental Health” recommended that national health insurance include dental care and that it prioritize child populations with a “basic system [that] assures the delivery of preventive [dental] services to all children.” The IOM’s 1995 Report “Dental Education at the Crossroads” addresses the need for a more medical approach to dental education, recommending that, “To prepare future practitioners for more medically based modes of oral health care and more medically complicated patients, dental educators should work with their colleagues in medical schools and academic health centers.” Specific recommended actions included basic science education that is integrated with medical students, clinical medical rotations for dental students, development of combined MD/DDS programs, and greater dental faculty experience with clinical medicine.

Adoption of disease management principles in dentistry has remained marginal across the last four decades, despite multiple efforts by government, educators, researchers, the professions and some payers (see Appendix). Thus, adoption has not followed the Diffusion of Innovation pattern described by Rogers in which new paradigms are adopted first by innovators, then by early adopters, then by the early majority and late majority, and finally by “laggards.” This failure suggests that strong environmental pressures continue to inhibit progressive changes in dental care that hold potential to redress disparities and improve oral health at reduced costs.
Are common oral conditions truly chronic diseases? If so, why are they treated as acute conditions?

The list of chronic diseases is lengthy—asthma, AIDS, arthritis, colitis, cardiovascular disease, stroke, diabetes, emphysema, lupus, osteoporosis and many more—but rarely does it include two of the most prevalent: dental caries or periodontal disease. Yet these two highly prevalent oral diseases share many characteristics with these chronic medical conditions.

Caries and periodontal disease are both long-duration, progressively destructive, ultimately debilitating, generally silent diseases that are marked by intermittent symptomatic exacerbations. Like other chronic diseases their causality is complex, involving multiple individual and environmental risk factors; they are persistent and their course is prolonged after a long latency period; and they produce a range of functional impairments, disabilities, and complications. Both have high rates of morbidity but not mortality. Caries sequelae include pain and oral dysfunction as well as extension of infection into the anatomical spaces of the face and neck and into the cranium where impingements and infections may result in complications that can be severe or devastating. Consequences of pediatric caries experience occur at the child (eating, induced malocclusion, missed school, inappropriate use of over-the-counter analgesics), family (parental missed work, family stress and reduced quality of family life), and community (inappropriate use of hospital emergency departments) levels. Periodontal disease is more surreptitious, typically creating local damage while also seeding infection and inflammatory byproducts to distant sites and worsening a variety of medical conditions.

Surgical treatments that repair damaged tooth surfaces, reposition gingival tissues, or replace teeth with implants are effective in restoring form and function but not in curtailing disease progression. Characteristic of chronicity, the best predictor of future cavities is past cavities, regardless of whether those past cavities were surgically repaired. The best predictor of future periodontal tissue destruction from aggressive periodontal disease is past periodontal disease, regardless of surgical treatment. These findings suggest that a reparative approach alone fails profoundly to reverse clinically significant underlying pathologic processes.
Like other chronic conditions, treatment for both caries and periodontal disease is resource intensive, particularly in late stages. Unlike acute conditions, their effective management requires collaboration between patient and healthcare provider as each has “complementary knowledge” required to control disease progression. Such collaboration holds promise for better outcomes as noted by Holman and Lorig who stress that “the patient must become a partner in the [disease management] process, contributing at almost every decision or action level. This is not just because patients deserve to be partners in their own health care (which, of course, they do) but also because health care can be delivered more effectively and efficiently if patients are full partners in the process.”

Successful disease control requires “self-management” by patients who are “informed and activated,” typically becoming so through their interaction with a “prepared practice team” and supported by a health-promoting care delivery system and community resources. (Figure)

Wagner contrasts such chronic disease management with acute care management and calls for systems changes to support these differences. His message is as relevant to dental care as to medical care:

“If we are to improve care for most patients with chronic illness, the evidence strongly suggests that we reshape our ambulatory care systems for this purpose. Primary care practice was largely designed ...with an emphasis on triage and patient flow; short appointments; diagnosis and treatment of symptoms and signs; reliance on laboratory investigations and prescriptions; brief, didactic patient education; and patient-initiated follow-up.

Patients and families struggling with chronic illness have different needs, and these needs are unlikely to be met by an acute care organization and culture. They require planned, regular interactions with their caregivers, with a focus on function and prevention of exacerbations and complications. This interaction includes systematic assessments, attention to treatment guidelines, and behaviorally sophisticated support for the patient's role as self-manager. These interactions
must be linked through time by clinically relevant information systems and continuing follow-up initiated by the medical practice.”

The stated contrast between “didactic patient education” in acute care and “behaviorally sophisticated support for the patient’s role as self manager” in chronic care is central to this shift in perspective. The first typically takes the form of instruction. It is often “one-size-fits-all” for a given condition (e.g. caries and periodontal disease advice offered at semiannual “recall visits”) and, in contrast to the second, fails to be a “behavioral process based largely on an individual’s ability to self regulate.” Jack Meyer of Health Management Associates notes that “education-only interventions tend to be less effective… than follow-up from higher-intensity interventions that are winding down to the level of patient self management.” An individual’s capacity to self-regulate, in turn, depends upon social and psychological determinants as well as biological determinants. For this reason, chronic disease interventions need to cross “medical-social boundaries;” need to rely on a treatment team that includes case managers and non-traditional providers of care; and need to focus on “treatment of the patient with the disease, not simply treatment of the disease in the patient.”

Such envisioned disease management cannot function either within the current boundaries and incentives of an acute care model nor as isolated nodes of patient-provider interaction. Rather “broad based reforms” are required that modify financial incentives, change health provider education and training, link medical/dental care to patient-supportive care systems, incorporate quality metrics, and actively engage patients within the context of their families and communities.

According to Wagner, health systems that support such change

- “have well-developed processes and incentives for making changes in the care delivery system
- assure behaviorally sophisticated self-management support that gives priority to increasing patients' confidence and skills so that they can be the ultimate manager of their illness
- reorganize team function and practice systems (e.g., appointments and follow-up) to meet the needs of chronically ill patients
- develop and implement evidence-based guidelines and support those guidelines through provider education, reminders, and increased interaction between generalists and specialists, and
- enhance information systems to facilitate the development of disease registries, tracking systems, and reminders and to give feedback on performance.”
Typical dental practice today stands well outside of these characterizations. Dental care in the U.S. is overwhelmingly delivered by independent solo practices or small partnerships rather than within organized systems of care. Only about 5% of dentists practice in the dental “safety net” that includes health centers, dental schools, government services, and large group practices dedicated to underserved populations. With the exception of oral surgeons and pediatric dentists, few dentists belong to hospital staffs or engage in other healthcare “systems.” Patient appointments for dental care are procedurally determined rather than diagnostically based as there are no diagnostic codes employed by dentistry. Appointments are for procedures provided by hygienists (dental prophylaxis, topical application of fluorides, and oral health education) or by dentists (reparative services that correct for defects created by caries or periodontal diseases). The dental team is well developed and specialized in providing “surgical” interventions. Despite a broad evidentiary base and significant development of generic guidelines—particularly by the American Academy of Pediatric Dentistry and the American Academy of Periodontology—treatments commonly reflect payment incentives which almost exclusively reward technical rather than behavioral interventions. Adoption of health information technology, with the exception of business management functions (e.g. billings and appointments), has lagged in dentistry compared to medicine and few, if any, decision support or disease tracking software products are available in the dental market. Following payment incentives, most dentists “recall” patients on a fixed semiannual basis.

This “recall visit” is typically less focused on disease control than is proposed, for example, by the “Prodigy” guideline-based chronic disease decision-support system now used by some British primary care physicians. Prodigy has two components: a “disease management sequence over time” that offers the clinician therapeutic options for each recognizable stage of disease and a “consultation template” that describes specific actions to be taken at each sequential visit.

The economics of dental practice creates a powerful force for the status quo. Less than half of the US population (44%) seeks dental services in a year and subpopulations at greatest risk for dental diseases (minority, poor, and modest-education) obtain the least care. Evidence-based interventions
would markedly reduce the frequency and numbers of “recall” visits for low-risk individuals and thereby threaten the profitability of a typical dental practice, particularly in the care of children. Nonetheless, at a global level, risk-based disease management holds strong promise to both reduce dental care costs and to improve health outcomes for pediatric caries just as such approaches do in medicine when they target individuals at greatest risk. However, at the individual practice-level, concern about patient acceptance and office profitability coupled with lack of third-party payment for dental disease management impedes adoption even of established guidelines.

Self-selection of candidates for dental education and the structure of dental education itself further reinforce traditional characteristics of dental professional practice. Candidates for dental schools preferentially seek education that develops competencies in manual/surgical care rather than in cognitive/behavioral care. In this way they are often characterized as more like surgeons than primary care physicians.” Dental education builds upon biomedical studies to prepare students for introduction to surgical training in dental clinics with little experiential focus on pharmacological or behavioral interventions. For example, few dentists engage actively in tobacco cessation counseling despite recognizing the deleterious impact of tobacco on oral health.

As a result of inattention to medical management of chronic dental conditions, commercial efforts to promote disease management in dentistry with diagnostic and pharmaco-therapeutic products have largely failed to attract a wide audience of providers. The founder of one such company notes that selling disease management products required a “consultative sales organization since very little prevention is taught in dental schools and continuing education courses on disease management are filled with hygienists [who do not make purchasing decisions], not dentists.” Detailing impediments to shifting the dental practice culture toward disease management, he explains that, “Our sales staff learned the latest cariology science so that they became experts for the offices on what is the latest in prevention. We misted kerosene on the flames of change and the fire grew but in a limited space. Only about 30% of dental offices dispense products from the office for patient at-home use (beyond toothbrushes and toothpaste samples) and instead prescribe or do
It is estimated that more than half of all dental prescriptions never get filled. Many pharmacies do not carry much more than generic chlorhexidine and Prevident® [a high fluoride concentration therapeutic toothpaste]. Anything past that is special order, and the patient usually does not bother. Also, many patients believe, rightly or wrongly, that dental prescriptions are not covered.”

Reflecting on the differences between traditional surgical/reparative care and preventive/disease management care, the industry executive comments:

“Restorations provide instant feedback. Prevention is faith-based. In the absence of pain there is no way of really seeing if a tube of therapeutic dentifrice is doing anything. For us it was constantly reminding offices, through our sales organization, that they were doing good, doing what was right, accepted, and cutting edge. The model was 1) staff meeting 2) product sale 3) reminder visit where often you find that the boxes of product are unopened (after the staff meeting and the order placement the speed of the office takes over and good intentions fall away) 4) reinforcement and commitment of a reminder visit 5) follow-up staff meeting. Then, after a dispensing rhythm begins, the trick is to train new staff that come into the practice and track down old staff that was trained at offices that are likely not yet believers.”

CDC’s Division of Oral Health seeks to support such individualized interventions while also promoting interventions at the community level. It champions progress made from fluoridation and dental sealants yet recognizes that oral disease burden remains extreme; that disparities in oral health are profound; and that poor nutrition is a significant contributor to chronic conditions. Consistent with the CDC Division of Oral Health’s four strategies (strengthen state oral health programs that target the most vulnerable populations; promote oral health in communities, schools, and healthcare settings; support research to strengthen prevention at the community level; and evaluate cost effectiveness of preventive strategies), it is now supporting systems dynamics modeling on early childhood caries prevention and management that suggests the potential for improved oral health at lower costs through a combination of personal and community-level interventions.

At the community level, caries and periodontal disease fit the CDC’s description of chronic diseases as those that “are not prevented by vaccines or generally cured by medication, nor do they just disappear. To a large degree [they] are an extension of what people do, or not do, as they go
about the business of daily living. Clearly, promoting healthy behavior choices, through education and through community policies and practices, is essential to reducing the burden of chronic diseases. CDC’s National Center for Chronic Disease Prevention and Health Promotion (wherein the Division of Dentistry is placed) further calls for early intervention for greatest effectiveness (like the American Academy of Pediatric Dentistry’s “age one dental visit”). It advocates for behavioral research that supports adoption of healthy behaviors, incentives to promote early detection practices, improving the health of communities, and supporting public health interventions.” As such, it is consistent with Wagner’s model that puts individual health care within the larger contexts of delivery systems and communities. CDC’s broad approach, like Wagner’s model, also exacerbates the “boundary problem” between health and health care by recognizing that health is obtained and maintained by many factors beyond the traditional reach of health care per se. As described by the National Health Policy Forum, “many health policy analysts increasingly … recognize that personal health behaviors, social and economic factors, the physical environment, and genetics all play significant roles in overall health. In most cases, these factors are more important determinants of health than access to health care services.”

What is insufficient about surgical therapies for caries and periodontal disease?

With the exception of one infrequently used dental reparative material (glass ionomer cement), dental repair itself does not dampen the underlying caries process. As a result, individuals with significant cariogenic activity tend to experience significant disease recurrence. Among the most acutely impacted are young children who require dental repair under general anesthesia. Ng at Children’s Hospital Boston reports that “Once definitive dental repair is provided, including frequently under sedation or general anesthesia, many [young] children experience unacceptably high rates of cavity recurrence (23-57% within 6-24 months).” Berkowitz at the Eastman Dental Center reported in 1997 that over half of children treated under general anesthesia with comprehensive dental repair had new lesions within six months; in 2003 that approximately 40%
relapsed, observing that “primary prevention of ECC has largely been restricted to counseling
parents about caries-promoting feeding behaviors…with minimal success;”\textsuperscript{59} in 2004 that about the
same percentage (37\%) relapsed within six months and that “aggressive dental surgery for ECC does
not result in acceptable clinical outcomes”;\textsuperscript{60} and in 2006 that 60\% relapsed within one year and that
“even prophylaxis, fluoride gel application and complete surgical treatment of caries at baseline were
insufficient to prevent new caries.”\textsuperscript{61} Observing over two years, Almeida and colleagues reported
79\% relapse with nearly one-in-five children (17\%) requiring re-hospitalization concluding that
“more aggressive preventive therapies may be required to prevent the future development of carious
lesions in children who experienced ECC.”\textsuperscript{62} These failures are cumulatively substantial: the 2006
National Survey of Ambulatory Surgery identified 146,000 cases of children under age 15, including
112,000 for children under age six being treated under general anesthesia for dental caries.\textsuperscript{63} Despite
high failure rates, such treatment is highly costly (in the range of
$7000/case) with significant impact on Medicaid programs as low-income children are more often and
more severely impacted by caries. About 5\% of children in Medicaid and CHIP, primarily young children
treated for extensive repair, consume about 30\% of dental program costs.\textsuperscript{64} Among Native
American children, caries prevalence is extreme. The Director

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\begin{tabular}{|c|c|}
\hline
\textbf{Risk factors for periodontitis.} & \\
\hline
\textbf{MICROBIAL RISK FACTORS} & \\
\hline
\checkmark Specific periodontal pathogens\textsuperscript{*} & \\
\checkmark Pathogenic potential of the biofilm\textsuperscript{†} & \\
\checkmark Total microbial burden\textsuperscript{†} & \\
\hline
\textbf{SYSTEMIC RISK FACTORS} & \\
\hline
\checkmark Diabetes mellitus\textsuperscript{*} & \\
\checkmark Genetic risk factors (genes controlling proinflammatory cytokines)\textsuperscript{†} & \\
\checkmark Sex (male), race/ethnicity (African-American)\textsuperscript{†} & \\
\checkmark Osteoporosis\textsuperscript{‡} & \\
\checkmark HIV infection\textsuperscript{‡} & \\
\checkmark Psychological factors\textsuperscript{‡} & \\
\hline
\textbf{BEHAVIORAL RISK FACTORS} & \\
\hline
\checkmark Tobacco use and cigarette smoking\textsuperscript{*} & \\
\checkmark Patient compliance (oral hygiene practice and regular dental visits)\textsuperscript{†} & \\
\hline
\textbf{LOCAL RISK FACTORS} & \\
\hline
\checkmark Faulty dental restorations\textsuperscript{†} & \\
\checkmark Untreated dental disease\textsuperscript{†} & \\
\checkmark Dental anatomy and malocclusion and furcations\textsuperscript{‡} & \\
\hline
\end{tabular}
\caption{Risk factors for periodontitis.}
\end{table}

\textsuperscript{*} Primary risk factor (strong relationship, supported by association, prospective cohort and intervention studies).
\textsuperscript{†} Secondary risk factor (moderate relationship, supported by association studies).
\textsuperscript{‡} Tertiary risk factor (limited supporting data).
Division of Oral Health wrote in February 2010 upon introducing a new IHS Early Childhood Caries Initiative that “we really haven’t made significant progress with the problem of ECC.”

Periodontists have long labored to address personal oral hygiene practices as primary determinants of periodontal health and have developed risk tools and treatment guidelines in an effort to identify and manage those who are particularly susceptible to the most devastating conditions (see box at left). At this time, the best predictor of progression of aggressive periodontitis is past experience with the disease. Lacking but in development are definitive genetic tests for host susceptibility. Promising work in this field has not translated well across populations of different races and ethnicities. More promising are tests of crevicular fluid and saliva for inflammatory markers that accumulate prior to actual tissue destruction.

Much of periodontal specialty care has shifted toward extraction of periodontally involved teeth and subsequent surgical replacement with dental implants. However, the same pathologic processes that establish gingivitis and periodontitis also affect implants, making tooth replacement in the absence of disease control an unsatisfactory resolution. There is limited evidence that surgical approaches to peri-implantitis, any more than to periodontitis are effective in resolving these lesions. Nonetheless, general dentists and periodontal specialists are doing less gingival surgery for adults than in the past. The American Academy of Periodontology in 2006 released “Guidelines for the Management of Patients with Periodontal Diseases” that is firmly grounded in chronic disease understanding stating, “[The] evolving paradigm in the treatment of chronic diseases, such as periodontal diseases, not only identifies the existence of disease and its severity, but also considers factors that may influence future progression of disease.” Research efforts to develop and refine a periodontal disease risk assessment tool that has strong prognostic power are underway. For high risk patients, behavioral interventions focus on specific oral hygiene improvements combined, as needed, with topical and systemic antibiotic therapy that complements thorough cleaning (scaling and root planing) by the dentist or hygienist.
The Boundary Problem in chronic disease management

Dentistry faces the same boundary problem as does primary care medicine in effectively addressing the chronicity of the diseases it treats. If traditional surgical dental repair does not suffice to successfully “treat” oral conditions (as evidenced by disease progression and “relapse” after surgical treatment), what then is the responsibility of the dentist or physician? Further, if oral health attainment and maintenance is truly appreciated as multidimensional (Figure below) and significantly regulated by factors outside of the clinical milieu, what then is the role of the dentist in oral disease management? Concepts and tools such as social determinants of health, social medicine, and lifecourse analyses tend to blur distinctions between health and health care and challenge the limits of dental care. For example, statistical modeling of determinants of children’s oral health status identified 15 domains at the child, family, neighborhood, and state levels that were significantly predictive. Of these, only one involved use of dental care. The authors conclude that “efforts to improve children’s oral health should consider a multilevel approach that goes beyond solely child-level factors” thereby furthering confusion over the role of dental care per se.

The multiple determinants approach also helps
explain oral health disparities since those who lack strong personal, family, and community support are inherently more susceptible to disease. Among such populations are not only the poor, immigrant, migrant, and those with limited education, but also populations whose characteristics render them physically or developmentally vulnerable or dependent including adolescents, pregnant women, frail elders and those of all ages with special healthcare needs.

**The incentive/intention problem**

If dental care were to shift overtly toward a chronic disease management approach, the public may question care that is more motivational and behavioral than technical and procedural. Unless thoughtfully implemented and well supported by financing incentives, a switch to motivational interviewing, anticipatory guidance, risk assessment, individualized counseling, tailored care plans, pharmacologic interventions, and facilitated health behavioral change will violate patients’ expectations of dental care. The public may be expected to raise concerns over value and appropriateness which could negatively impact elective use of services. Andersen, in his *Behavioral Model of Health Services Use* recognizes perceived need (as well as actual physical need) as a prime determinant of health services use. Thus, if the public does not recognize the value of chronic disease management for caries and periodontal disease, it will not perceive need (until acute) and will be less likely to utilize services. With regard to dental services in particular, Andersen notes that “social structure, beliefs, and enabling factors” including income and dental insurance coverage are critical to transforming “potential access” into “realized access” and that perceived needs then play a role in “equitable access.” In sharp contrast, use of hospital services for acute conditions is driven more by immediate physical needs and demographic status than by normative values for care and presence of strong enabling factors.

The *Behavioral Model of Health Services* also suggests that inequitable access results when social structures, health beliefs, and financial considerations determine who can access care rather than when physical need drives use of services. As access to dental care is more fundamentally related to the former conditions than the latter (except when oral symptoms are acute), dental care can be predicted to be more
inequitably distributed than medical care. Thus the Andersen model reflects limitations and inequities in dental care that result from the geographical maldistribution of dentists (social structures), the lesser and more acute-care oriented use of services by low income and minority populations (health beliefs), and the lack of dental coverage in Medicaid and health reform for adults and relative lack of employer-sponsored dental coverage in low-paying jobs (financial considerations).

Not only will patients’ values and perceptions drive use of progressive dental services but so too will dental providers’ values and perceptions. The current dental delivery model, dental education and training practices, and payment incentives all reward surgical interventions over medical interventions. Dentists are well aware that among physicians, surgeons are more highly compensated than are cognitive and primary care practitioners and that dentists currently earn higher salaries than primary care physicians. As a result, there is currently no economic motivation to adopt a chronic disease management approach. Beyond financial considerations, the Azjen and Fishbein Theory of Reasoned Action may be particularly useful in understanding dentists’ reticence to shift gears toward a combined disease-management and surgical approach to delivering care. In this context, the Theory considers motives, attitudes, and characteristics of the practitioner which are then mediated through social norms, competencies, and attitudes about the patient before yielding an intention to act. The Theory further accommodates logistical barriers that may exist between intention and action.

In the case of dentists adopting a bio-behavioral or pharmaco-behavioral rather than surgical approach to care, individuals who self-select into dentistry are very likely to have a strong surgical mindset (“like to work with my hands”), seek a health profession that provides for significant levels of independence, and seek opportunities as small business persons or as employees of small businesses. These characteristics intrinsically dampen receptivity for training and practice of “cognitive” care—a bias that is reinforced and institutionalized through the experiential education of clinical dental training which is predominantly overseen by private practitioners who share their “real world” perspectives with students. Practitioners’ perceptions and categorization of patients as having “high or low dental IQs” reflects dentists’ presumptions and biases about equivalency between their own values for oral health and
the values of those whom they treat. (For example, the dental literature is rife with characterizations of Medicaid-insured patients as having “low dental IQ.”) Regarding competencies, only about 10-15% of graduating dental students each year report on American Dental Education Association’s outgoing student surveys that they feel “well prepared” (as opposed to “prepared” or “unprepared”) to “adapt treatment planning to low income populations,” to “provide oral health care to a diverse population,” to “provide care in a rural area” or to “provide pediatric oral health care.” Regarding social norms, expectations that are explicitly or implicitly expressed by dentists’ peers and professional colleagues, their staffs, their patients, and their families and friends, collectively reinforce the status quo. Application of the Theory suggests that adoption of normative values and behaviors acts as a strong inhibitor to change. Thus, according to the Theory of Reasoned Action, dentists would not reasonably be expected to “buck the norm” by establishing practice behaviors that run counter to their motives for entering the profession, their training, their sense of competencies, their peer groups, or their perceptions of patients’ values. In this conception, lack of insurance coverage, lack of definitive disease management protocols, lack of an organized “system” of dental care, and lack of HIT support for disease management are secondary to lack of “intention” that would lead to “action.” Rather, such barriers sit between intention and action.

Summarizing systematic disincentives to providing comprehensive well child preventive care in medicine that are equally applicable to dental care, Commonwealth’s Ed Schor notes that:

“Time constraints, low levels of reimbursement … lack of training …, lack of trained … staff members, limited access to community services to support families and children, and few external incentives have all been reported as reasons why the needs of children and families for preventive pediatric care services are not being fully met. Most of these barriers are systemic rather than personal. As a group, pediatricians are committed to providing high-quality care to their patients.”

**Institutionalizing a complementary disease management component in dental practice**

A variety of concepts and models may be useful in promoting the adoption of disease management in dentistry that complements and augments the current surgically-focused approach to care. Using childhood caries as the exemplar, a sampling of these include:
1. **Clinical models:** *Bright Futures in Practice* and its companion, *Bright Futures Oral Health*, detail developmental stage-specific pediatric well child guidance for healthcare providers and parents in preventing common diseases including dental caries. The American Academy of Pediatrics has long advanced—and the American Academy of Pediatric Dentistry has significantly adopted—approaches that include individualized care in a “medical home” that offers a spectrum of services from anticipatory guidance, primary prevention, disease management that reduce disease occurrence to therapeutic care or care-coordination that ensures definitive reparative treatments when needed. AAPD’s extensive policies and guidelines provide structure, albeit yet unvalidated, for these approaches with a particularly strong focus on risk assessment and associated risk-specific care paths. Similarly, “Caries Management by Risk Assessment (CAMBRA)” is a multifaceted effort to move the dental profession from a focus on repair to a disease management.

Both AAP and AAPD actively promote a clinical synthesis between primary care medicine and primary care dentistry wherein the pediatrician, family doctor, or pediatric nurse practitioner provides risk assessment, oral health counseling, application of fluoride varnish, and early referral and the dentist provides a “dental home” that parallels the child’s “medical home.” However, significant dentistry does not have sufficient capacity to allow access for all children and risk-based alternatives have been advocated to address this shortage of dental providers. The Iowa “I-Smile” program is exemplary by adopting risk-based triage for preferential oral health supervision and by engaging multiple provider types rather than dentists alone. Additional notable state-level access efforts that target young low-income children include the Washington State “ABCD” (Access to Baby and Child Dentistry) that trains dental offices in early intervention and provides an enhanced Medicaid payment and the North Carolina “Into the Mouth of Babes” program which trains primary care physicians. Physician engagement has become widespread with 34 state Medicaid programs (as of 7/10) paying medical offices to counsel on caries and apply fluoride varnish. Americhoice insurance (United Insurance Company’s Medicaid division) has used financing
incentives to encourage physician engagement, particularly in effectuating a successful referral to dentists. Its New Jersey plan pays a small bonus to physicians who have completed an oral health intervention when the referred toddler also completes an initial visit with a dentist. A model community-based clinical program that involves outreach, education, disease management, and restorative treatment was recently instituted by the University of Washington as the Early Childhood Oral Health Center.87, 88

Some medical practices, particularly those within systems of care (integrated health plans, community health centers, and large group practices) have gone even further in reconceptualizing clinical care by broadening the range of midlevel providers to deliver basic care so that physicians can concentrate on the most complex condition and patients. Parallel efforts for dentistry are now in development but remain highly controversial. According to the National Health Policy Forum, these medical practices’

“use of health information technology has further widened the scope of such practice innovations and holds the promise of involving patients more effectively in the management of their own health. These practice innovations can relieve access pressures and reduce costs. But fee-for-service payment incentives, inter-professional tensions, state practice laws, and the costs of health IT have inhibited their adoption.”89

The Commonwealth Fund also promotes a vision of well child care that reflects many of these same approaches. It “would be characterized by advanced access to services, team based care, individualized …screening, care coordination through a medical home, electronic health records, and tools for information and knowledge transfer.”90

Strengths of these clinical approaches are that they can be readily incorporated into the existing dental delivery milieu without significant disruption to current practice organization. Limitations on their adoption relate significantly to lack of insurance coverage for disease management. The primary weakness of the approach is that its scope is constrained by a clinical paradigm. It adopts a disease management overlay for the individual without addressing the larger environmental contextual determinants of disease. It has been suggested that health care itself contributes only modestly (estimated to be 10%) to health status with genetics, environment, health
behaviors, and societal factors being more influential.\[^91\] Strengths of approaches that involve primary care medical providers as well as dentists are that they broaden the base of dental care and mainstream oral health into general health care, thereby crossing the longstanding medical-dental divide. They too generally lack financing incentives from private insurers that would speed their adoption although they have been widely adopted in Medicaid.

2. **Cross-Boundary models that combine clinical and public health interventions:** In 2004 the National Research Council and Institute of Medicine promulgated a definition of children’s health that is holistic and comprehensive stating, “Children’s health should be defined as the extent to which individual children or groups of children are able or enabled to (a) develop and realize their potential, (b) satisfy their needs, and (c) develop the capacities that allow them to interact successfully with their biological, physical, and social environments.”\[^92\] This expansive definition built upon recognition that pediatric infectious diseases are now largely controlled, that chronic diseases are largely manageable, and that wellness for all should now be the aim of health promotion and health care. This perspective reflects the boundary issue described above as it is inclusive of biological, psychological/behavioral, physical, and social influences at levels of child, family, community, and society (figure). According to
Halfon: “This new definition is rooted in an empirically based conceptualization of health as the product of dynamic, lifelong interactions between risk, protective, and health-promoting influences that affect long-term health trajectories. Considering child health in relationship to how health develops across the life course enables a new logic for achieving the goals of child health care. Because the health of children is influenced by nested and interactive patterns of biological, behavioral, family, social, environmental, and policy factors, effective approaches to health development seek to minimize risks, protective factors, and optimize health promotion.”

This type of model has been applied to children’s oral health as a number of efforts have been made to explain the complex etiology of dental caries as a chronic disease within broad contexts. The ECC model displayed above (pg. 19) was first published as a concept and later assessed empirically using parental reports of their children’s oral health on the National Children’s Health Survey as the dependent variable. Factors associated with ECC status were identified at the child, family, neighborhood, and state levels. Among significant correlates of ECC were minority

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**INFLUENCES ON ORAL HEALTH AND ORAL HEALTH DISPARITIES**

1. Individual Status-Demographic: Genetic, Ethnicity, Age, Gender, Achieved Education, Income, Occupation
2. Distal
   - Macro
     - Natural Environment: Natural occurring in water, geography / climate
     - Macrosocial Factors: Dentistry in health services and public health, political support for dentistry, support for sugar and confectionaries, advertising sugar-laden products, legal system and legislation
   - Inequalities: Dental caries disparities, oral health disparities, disparities in opportunity related to oral and craniofacial conditions
3. Intermediate
   - Community
     - Physical Environment: Location of dental services, artificial toothwear, sugar in environment, e.g., schools, vending machines, soda and candy
     - Social Environment: School curricula, community education, community practices, social stigma
   - Cultural Environment: Beliefs about oral health, access to dental care
   - Organization & Delivery of Services: Supply of dentists, number and distribution of minority dentists, dental insurance, reimbursement for dental treatment, technological diffusion among dentists, dental practice regulation
4. Immediate
   - Interpersonal
     - Stressors: Homelessness, persons with cognitive impairment, HIV, dental-patient interaction
5. Proximal
   - Individual Biological Processes: Host defense, Streptococcus mutans
   - Health Behaviors: Sugar consumption, alcohol and smoking, oral hygiene practice, delay in seeking dental care
   - Type and Use of Services: Motivational interviewing
   - Individual Psychology: Taste preference for sugar, fear of dentists and dental treatment

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Health & Well-being
- Health Outcomes: Oral health
- Health Behaviors: Sugar consumption, alcohol and smoking, oral hygiene practice
- Type and Use of Services: Motivational interviewing
- Individual Psychology: Taste preference for sugar, fear of dentists and dental treatment

Well-Being and Quality of Life
- Oral-related quality of life

Life Course

- Birth
- Death

*Based on Patrick and Erickson, 1993 and Schulz and Northridge, 2004. Boxes contain only selected examples of influences in italics; readers are suggested to think of additional examples.*
race and ethnicity; having been breastfed; lacking dental insurance or a parent lacking health
insurance; lack of dental care; poor physical or mental health of a parent; unfavorable neighborhood
environment; and the state’s level of community water fluoridation.

A conceptual model by Patrick et al\(^6\) additionally considers lifecourse to explain oral health
quality of life and oral health status (figure above). According to this model, the “organization and
delivery of [healthcare] services” is a “macro” determinant of ECC that occurs far “distal” to the
health outcome while “access to oral health care” is a “community” determinant that is
“intermediate” to ECC development and the “type and use of services” is an “individual”
determinant that is proximal to ECC outcomes.

The Association of State and Territorial Dental Directors has promoted a strategic
framework for its “Best Practices Approach to Prevention and Control of Early Childhood Tooth
Decay”\(^7\) (figure) that nests prevention within disease management which in turn is nested within access to dental services within integration and care coordination. This
model effectively addresses a portion of the boundary issue by placing disease management within
the context of the delivery system but does not consider other contextual issues beyond healthcare
itself. This approach reflects the Maternal and Child Health Bureau’s “Pyramid of Health Services”
that similarly builds “direct health care services” on top of “enabling services” which in turn depend upon “population based services” and “infrastructure services” (figure).

Linking individual level care to public health interventions that address the boundary issues, CDC Director Thomas Frieden has proposed the “Health Impact Pyramid” (figure) that suggest multiple levels of potential intervention to prevent and control disease. From the perspective of ECC, “changing the context to make individual’s default decisions healthy” could include reducing the availability of cariogenic foods in the community; delivering “long lasting protective interventions” could include assurance of fluoridation; “clinical interventions” could include improved systems of integrated care between physicians and dentists; and “counseling and education” could include the effective use of motivational interviewing (which has been demonstrated to be effective in ECC management98).

For pediatrics, Halfon and colleagues have proposed a transformation of healthcare for
children that assumes a new logic model reflecting that “health is not endowed at birth but instead
develops over
time” and
includes
“biopsychosocial
dimensions of lifecourse health development
(figure).” The Harlem Children’s
Zone provides an example of such a comprehensive holistic effort that combines community-based
educational, social, nutritional, and medical services to meet children’s needs in ways that promote
health. Its health programming is predicated on attention not only to health care but to addressing
the multi-level determinants of oral health status. Founder Geoffrey Canada described his approach
as "want[ing] to see … our community look like middle class communities, where kids had
healthcare, where kids got their teeth fixed from the dentist, where kids were not obese and they were
eating nutritional meals, where young people didn't have to worry about gangs and being shot and
being killed," Within the Children’s Zone initiative, health care is an integral part of a “safety net
woven so tightly that children just can’t slip through.” Examples of interdisciplinary approaches to
health include the Zone’s asthma initiative and its “healthy living” obesity initiative. Both intervene
to promote health through educational and behavioral as well as medical care.

<table>
<thead>
<tr>
<th>EXHIBIT 3</th>
<th>Comparison Of Old And New Logic Models For Child Health Systems</th>
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<tbody>
<tr>
<td></td>
<td><strong>Old logic model</strong></td>
</tr>
<tr>
<td>Definition of health</td>
<td>Absence of disease, disability</td>
</tr>
<tr>
<td>Goals of the health system</td>
<td>Prolonging life, health maintenance</td>
</tr>
<tr>
<td>Client model (stakeholder)</td>
<td>Individual</td>
</tr>
<tr>
<td>Causal model</td>
<td>Biomedical</td>
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<tr>
<td>Intervention approach</td>
<td>Diagnosis and treatment</td>
</tr>
<tr>
<td>Time frames</td>
<td>Episode of care</td>
</tr>
<tr>
<td>Delivery and organizational focus</td>
<td>Vertical hierarchy of primary, secondary (specially), tertiary care</td>
</tr>
<tr>
<td>Financing approach</td>
<td>Episodes of care, with a focus on medical conditions as insurable loss and preventive care as prepaid benefits</td>
</tr>
<tr>
<td>Performance improvement</td>
<td>Condition-specific quality improvement</td>
</tr>
</tbody>
</table>

**SOURCE:** Authors’ analysis.
Strengths of such comprehensive approaches are that they are integrative and dynamic. Weaknesses are that they are large and complex and therefore difficult to develop and effectively administer.

3. **Research and demonstration models:** Statistical modeling of ECC increments (that explained 86% of the variation) among children in Head Start by Litt et al (figure) confirm that the extent of prior caries is the best predictor of additional caries development and that *mutans streptococci* (aciduric and acidogenic bacteria associated with caries) are also predictive as an upstream measure. Other biological, psychological, and social factors associated with caries prevalence were not predictive of incidence and access to care was not considered. At baseline, self efficacy, oral health knowledge, and life stress were correlated with caries with stress inversely related. Conversely stress has been correlated with ECC\(^{102}\) and has been posited as a primary determinant in child health with ramifications for conditions with adult-onset among low-income populations.\(^{103}\)

A highly promising quality improvement intervention utilizing the Institute for Healthcare Improvement’s methodology (recurrent cycles of “plan, do, study, act”) at Children’s Hospital
Boston has demonstrated that caries risk and caries experience among young children can be reduced through pharmaco-behavioral management. After 21 months, new cavitations were reduced from 72% to 22%; parental reports of their children’s dental pain was reduced from 20% to 10%, and the percentage of children referred for surgical repair under general anesthesia was reduced from 20% to 9%. Demonstrating the situational and personal influences in the success of such programs, a parallel program at another children’s hospital yielded much more modest results.

NIH is currently funding over 20 studies that relate to pharmacological, behavioral, or social ECC determinants or interventions including a consortium project of Centers to Reduce Oral Health Disparities that is now preparing for clinical trials. The Dental Institute’s Behavioral and Social Sciences Research Branch supports a range of basic and applied behavioral, health communications, chronic disease management, and health disparities studies. These and other studies collectively add to the small but expanding weight of evidence supporting ECC management that are reflected in the Cochrane Collaborative’s evidence based reviews and protocols and the Scottish Intercollegiate Guidelines Network’s guideline on early childhood caries management. The Center for Minority Health and Health Disparities also supports ECC interventions including development of a iPad-based risk and family-level action planning tool dubbed MySmileBuddy® that is predicated on Prochaska’s Transtheoretical Model of behavioral change and is delivered by a community health worker.

Systems dynamics modeling has been recently applied to ECC bio-behavioral management to test alternative clinical and public health approaches that include simulations for groups of children at various levels of risk. These simulations factor a wide range of interventions including: educational programs, efforts to reduce maternal-child transmission of cariogenic organisms, use of Xylitol as a sugar substitute, fluorides (expanded use of fluoride varnish, increased use of fluoridated toothpastes, increased community water fluoridation), aggressive early screening coupled with clinical caries management, targeted disease management among children with extant cavities, and motivational interviewing.
The strength of these reviews and modeling efforts are their objectivity and potential influence on evidence-based guidelines. The weakness is that there is typically insufficient evidence to answer questions of clinical and public health significance. The strength of research and development models is that they are often novel, cutting edge, and focused on practical solutions. Their potential impact, however, may be limited by professional reticence to adopt science- and evidence-based findings into practice.

4. Behavioral models: Two levels of behavioral change are required if ECC is to be addressed through engagement of patients and families who are “prepared, informed, and motivated” for “self-management” as is central to “chronic disease management” approaches. Firstly, providers must change their behaviors by shifting from simple instruction to effective engagement with parents. Secondly, parents and families must change their behaviors through goal setting, action planning, and reinforcement of incremental achievement. The first requires provider training and has been shown effective in ECC management by physicians and nurses who utilized the “4 A’s” approach to counseling: “assess, advise, assist, arrange.”110 This approach, first develop for smoking cessation, has been expanded to include “5 A’s” by adding “agree” between advise and assist111 and “6 A’s which begins with “ask.”

Similarly, motivational interviewing (MI) and its characterization as “health coaching” has been shown effective in primary care medicine112, 113, 114 and in ECC management115, 116. MI principles that distinguish it from simple instruction include expressing empathy, identifying discrepancies between what exists and what is desirable, avoiding argumentation, rolling with resistance, and supporting self efficacy.117 MI is often coupled with intensive follow up through return visits, brief telephone consultations, or use of electronic tracking and reporting devices. This specialized approach to patient interaction is consistent with and supportive of a range of behavioral change theories and models that seek to identify patient motives, explicate perceived barriers, set goals, and develop action steps. These include but are not limited to learning theory, the health belief
model, the transtheoretical model, the relapse prevention model, the theories of reasoned action and planned behavior, social learning/social cognitive theory, social support theories, and ecological approaches. Using a variety of constructs, these emphasize the importance of patient and family perception, goal orientation, and recognition of individual patient characteristics.

These approaches assume cultural competency, linguistic appropriateness, and adaptation for a patient’s level of education. In envisioning a “New Health Care System for the 21st Century,” the Institute of Medicine reflected these values by calling for a healthcare system that respects patients’ values, preferences, and expressed needs; coordinates and integrates care across boundaries of the delivery system; provides the information, communication, and education that people need and want, and guarantees physical comfort, emotional support, and the involvement of families and friends.118

The strength of behavioral models is that they explicate personal and interpersonal dynamics that underlie access and health behaviors. The weakness of their clinical adaptations has been that they are regarded by practitioners as intensive and time-demanding.

Opportunities for change

Based on the nature of common oral diseases and examples from medicine, opportunities for change include:

1. Interventions from public education to patient counseling that aim to
   a. reduce transmission of cariogenic flora from mothers and caregivers to children during the infant/toddler period.
   b. manage the biofilm through hygienic and dietary practices to maintain homeostasis.
2. Further development of risk models and evidence-based protocols to support anticipatory guidance, primary prevention, and disease suppression.
3. Creation of new “midlevel provider(s)” for patient counseling and oral health coaching.
4. Development of cross-boundary holistic/ecological approaches that address the social, behavioral, and psychological components of oral health risk and expression.
5. Development of health information technology to support pharmaco-behavioral interventions and systems of dental care, including patient follow-up devices.

6. Development of dental/medical insurance financing models that support and encourage oral disease management through risk reduction, individualized care, and patient engagement.

Taken together, these approaches which have been explored in medicine hold strong promise to improve oral health while potentially reducing costs by limiting the need for reparative care.
APPENDIX

Evidence of Interest in Oral Disease Management

A wide variety of efforts by professional associations, government, foundations, academe, industry, and policy organizations actively promote a shift in caries management from surgical to medical. A sampling of these includes:

- Professional association actions:
  - Borrowing from pediatric medicine, the American Academy of Pediatric Dentistry has promoted concepts of dental home, early intervention, risk assessment, anticipatory guidance, and risk-based care paths.\textsuperscript{119}
  - The American Academy of Pediatrics (AAP) and the American Academy of Family Physicians have each developed online caries management training programs for their members.
  - The American Dental Association has developed caries risk assessment tools for adults and children.
  - AAP’s Bright Futures Guidelines for Health Supervision include a robust set of recommendations on children’s oral health promotion and management (cite Bright Futures).
  - The California Dental Association has strongly promoted caries management nationally and internationally under the moniker “CAMBRA”\textsuperscript{120}—Caries Management by Risk Assessment. It has published two issues of its journal on CAMBRA, promoted a CAMBRA implementation guideline, convened national conferences, and created international CAMBRA Coalitions.

- Federal Government actions:
• The National Institute for Dental and Craniofacial Research Health Disparities Research Program recognizes that caries is concentrated in low-income and minority populations and has established a goal of “exploring the biological, environmental, social, behavioral, psychological, cultural and contextual aspects of disparities/inequalities as well as their interactions; health literacy; and systems-level all of which to inform subsequent tailored/targeted interventional research.”121 (This wide ranging goal reflects current thinking about chronic disease management in medicine.)

• The Maternal and Child Health Bureau sponsored development of an on-line training program for state MCH officials on pediatric caries management (cite Opening the Mouth).

• Head Start is actively encouraging early establishment of a dental home (cite AAPD/HS initiative) and many WIC programs include oral health promotion (cite Jones).

• Based on high ratings by the Community Guide to Preventive Services, CDC aggressively promotes community water fluoridation and school-based dental sealant programs.

• CDC is currently exploring early childhood caries control options through systems dynamics modeling to assess costs and benefits of various public health and personal care interventions (cite Hirsh).

• CMS is adding a state Medicaid reporting requirement that measures dental caries prevention encounters delivered by primary care medical providers.

• State Government actions:

  • The Association of State and Territorial Dental Directors has established a “Best Practices Approach” to management of childhood caries.

  • State Medicaid programs are increasingly incentivizing early intervention and application of fluoride varnish by physicians. Among leading states are the WA “Access to Baby and
Child Dentistry (ABCD) Program” and the NC “Into the Mouth of Babes Program” both of which received initial funding from CMS.

- Foundation actions:
  - DentaQuest Institute currently supports a quality improvement (QI) approach to early childhood caries management at Boston Children’s Hospital and Providence Saint Josephs Hospital and operates an experimental disease management dental practice.\textsuperscript{122}
  - The Washington Dental Service Foundation and the University of Washington recently announced a free standing community-based Children’s Oral Health Center that will offer disease management services as well as traditional surgical repair, conduct research, and promote public policy.

- Academic actions:
  - The New York Academy of Sciences hosted an invitational conference in 2009 entitled, “Improving Pediatric Health through Bio-behavioral Interventions” that used ECC management as its exemplar.
  - The professional literature abounds with information on remineralization with nearly 100 citations on “dental remineralization” in Medline in the last 12 months alone.
  - The University of Washington convened a 2005 conference on “Biotechnology and Biomaterials to Reduce the Caries Epidemic.”

- Industry actions:
  - A small industry supplies dentists with diagnostic tools such as the CariFree\textsuperscript{®} Caries Susceptibility Test\textsuperscript{123} and the OMNI dental (now 3M Espe) product line of fluorides and Xylitol products.
• Policy organization actions:
  
  o The MCHB-sponsored National Oral Health Policy Center, managed by the Children’s
    Dental Health Project in collaboration with state MCH (AMCHP), health policy
    (NASHP), and Medicaid officials (MSDA), has released a series of three “Trend Notes”
    promoting state policies that support caries management.\textsuperscript{124}
8 National Health Interview Survey

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