Journal of Healthcare Leadership

Dovepress
open access to scientific and medical research

Open Access Full Text Article

REVIEW

Science-Informed Health Policies for Oral and Systemic Health

Harold C Slavkin[1], Peter A Dubois[2], Dushanka V Kleinman[3], Ralph Fuccillo[4]

[1]Ostrow School of Dentistry, University of Southern California, Los Angeles, California, USA; [2]California Dental Association, California Dental Association Holding Company, Inc., Sacramento, California, USA; [3]University of Maryland School of Public Health, College Park, Maryland, USA; [4]Cambridge Concord Associates, Stoneham, Massachusetts, USA

Correspondence: Dushanka V Kleinman, Email dushanka@umd.edu

Abstract: Oral, dental and craniofacial (ODC) health has a profound impact on general health and welfare throughout life, yet US dentists and physicians operate across misaligned silos. This protracted division limits access to optimal health, supports fee for services, and exacerbates health disparities. Early in the 20th century, the most frequent dental therapy was tooth extraction: removed infected teeth were substituted by prosthetic appliances – commonly, dentures or nothing. Most adults assumed becoming edentulous was a normal corollary of aging. With the discovery of penicillin and other antibiotics, healthcare professionals and policy makers predicted infectious diseases would become irrelevant. However, given numerous health threats, including SARS-CoV-2, HIV, multidrug-resistant bacteria, Zika virus, Ebola virus, and now monkeypox, public and professional awareness of transmissible infectious diseases has never been more evident. Ironically, little attention has been paid to unmet transmissible, infectious, common oral diseases – dental caries and periodontal diseases. Therefore, these persist within "the silent and invisible epidemic". The preventable death of a young boy in 2007 from an infected untreated tooth that produced bacterial meningitis is a profound reminder that our nation has vast inequities in education, health, and welfare. The impact of oral infections on hospital-acquired pneumonia, post-operative infection in cardiac valve surgery, and even academic performances of disadvantaged children displayed through sociodemographic characteristics and access to care determinants also are profound! This paper asserts that current and emerging ODC health knowledge and science will inform health policies and advance equity in access to care, affordable costs, and optimal healthcare outcomes. We recommend that legal and regulatory systems and public health programs be required to ensure health equity. A fair healthcare system that addresses holistic healthcare must be transparent, accessible, integrated and provide a standard of oral healthcare based upon scientific evidence for all people across the lifespan.

Keywords: dental caries, periodontal disease, primary care, health equity, research

Introduction and Scope of the Issues

There has been significant progress in the improvement of general health and well-being of the United States (US) population over the past century.[1–9] Most people are living longer. Eradication of illnesses, such as polio and smallpox, and breakthroughs in diagnosis and treatment for oral diseases have reduced morbidity and mortality for most, but not all, Americans. Health outcome improvements have resulted from increased access to health insurance and quality healthcare.[9–11] However, as we strive to achieve health equity, we need to confront and address the underlying barriers and realities facing the US.

Our nation continues to struggle to address disparities and inequities in education, income and health. These inequities are profound, complex and their interaction compromises individuals, families, and communities.[9–11] Prime among them is the lack of access to high-quality Pre-Kindergarten (Pre-K) and K-12 education, differences in income among working adults, limited access to care for vital life stagesfor example, prenatal care for all pregnancies, and the increasing prevalence of diseases and conditions that affect quality of life and functioning. Examples of diseases and conditions that represent 80% of our nation's disease burden include child and adult obesity, "the silent epidemic of tooth decay and periodontal disease" in poor children, poor adults and senior adults of color, mental health diseases and

Received: 4 November 2022
Accepted: 21 February 2023
Published: 16 March 2023

disorders, vision disabilities, autism, cardiovascular diseases, and dementias.[1,11] Upstream of these latter striking health disparities is the fact that 25% of the American population resides in environments where poverty and other social, educational, and health inequities exist.[12] The many forces at play causing poverty are complex. Poor education is a prime factor along with involvement in the criminal justice system or foster care system. Select disabilities and poor health, both physical and mental, are other cases in point. Conditions such as drug and alcohol abuse, child abuse and domestic violence add additional burdens.

Preventable gaps in health care contribute to the poor ranking of the US for life expectancy, infant mortality, oral health, and other health measures compared to other high-income countries, despite spending more on health care than other countries, both on a per-capita basis and relative to its wealth.[13,14] There are societal and economic consequences of these circumstances, and resulting inequities contribute to intergenerational transfers of disadvantage. This situation affects the health of future generations by limiting economic mobility and opportunity.[11] In addition, the structure and workforce of our healthcare system are a challenge. Primary care is under-resourced, presents clinician burnout, and all too often offers fragmentation of care. The National Academies of Sciences, Engineering, and Medicine (NASEM) have called for primary care to be defined as a "common good" and "not a commodity service".[15] Another significant issue for effective comprehensive primary care for all Americans remains implicit bias in healthcare delivery. These biases expressed by dentists, nurses, physicians, and other healthcare providers function within larger social, cultural, and economic structures and perpetuate systemic racism, gender inequity, sexism, and other forms of discrimination. It is estimated that health disparities cost the US economy as much as $1.24 trillion in excess medical and dental spending and lost work productivity.[16] The COVID-19 pandemic has further revealed the devastating effects of health disparities and the growing costs.[11] Addressing these and other challenges in the context of attaining health equity provides an opportunity to assess conditions, such as oral health and health care disparities, within the realm of health care and health care policies.

Ensuring health equity will improve the well-being of people and communities across the nation yielding economic and social benefits and saving lives. As defined by the Healthy People 2030 initiative, "Health equity is the attainment of the highest level of health for all people", and requires dedicated efforts to value "everyone equally with focused and ongoing societal efforts to address avoidable inequalities, historical and contemporary injustices, and social determinants of health".[17] The Centers for Medicaid and Medicare Services (CMS) extends this definition and includes a health equity framework to guide CMS and health care systems.[18]

Oral, dental and craniofacial (ODC) health is an essential component of health and well-being throughout the life span, but the evolution of health professions education and health care delivery systems have separated professional oral health care from overall health care. This separation has contributed to unmet dental needs and misdirected health care use. Fortunately, investments in science have led to discoveries that enhanced our knowledge and interventions to prevent and better manage oral and dental diseases. However, there is a gap between what is known and what is applied to personal, population and professional health care practices. This paper is a call to action to those in healthcare leadership to use the current and rapidly emerging science base related to ODC health to inform health policies and address health disparities in oral and systemic health. This gap can be filled by science-informed policy actions that support well-designed and evaluated oral health prevention strategies, integration of oral health into the practice and reimbursement of primary care and comprehensive health care. Selected examples are used to exemplify why and which actions are needed and why they are beneficial to the health and well-being of the US population.

Looking at Inequities Through the Oral Health Lens

The 2020 National Institutes of Health report, "Oral Health in America: Advances and Challenges", generated a call to action by the National Institute of Dental and Craniofacial Research (NIDCR) director, the National Institutes of Health (NIH) director, and the US Surgeon General to ensure oral health for all.[2,19] Using the "oral health lens" to look at our society and its key levers (education, economics, national security and health care) is enlightening. There are major upstream and downstream effects due to untreated oral diseases. Poor oral health is implicated in school attendance, work performance and productivity, employability, and long-standing challenges to eligibility for active military service. Poor oral health also is linked to substance use disorders and to all-cause mortality. The structure of our broken healthcare

system and the lack of a holistic approach to health further contribute to health inequities. A few examples highlight the broad impact of unmet dental and oral needs on society and on an individual, family and population level.

Untreated oral diseases and their symptoms are one of the major factors contributing to K-12 school days lost.[20–23] Poor school attendance due to toothaches results in lower academic achievement in grades K-12. In Thailand, school absence due to toothache is found in millions of children; essentially, one in every 20 school-age children.[24] In addition, oral conditions have been mentioned as one of the "individual" factors contributing to *chronic absenteeism*, defined as missing 10% or more school days per year (15–18 days).[25] Factors contributing to chronic absenteeism are extensive. Other individual factors include pain, asthma, obesity, and mental health issues. These individual factors are compounded by family conditions, such as poverty, concerns about school safety and structures, and community factors. Chronic absenteeism has been shown to be associated with achievement deficits, such as lower reading levels and national test scores, and with limitations in social development and engagement. Untreated oral diseases also have an impact on school funding, given that school attendance is a major driver for state funding of K-12 public education. For example, it is estimated (based on 2007–2008 data) that the Los Angeles Unified School District (LAUSD), the second largest in the nation with 450,000 students, loses approximately 30 million dollars per year due to students' lack attendance due to toothaches.[26] Subsequent studies of LAUSD school children documented additional savings that would occur with effective oral disease prevention programs partnering with the school district as well as the effect of days lost from school due to oral diseases on the academic performance of children.[20,27] The personal and societal impacts of lost school time are even greater for children living in poverty.

An extreme example of oral health inequity relates to access, affordability of oral healthcare, and optimal health outcomes occurred on February 28, 2007, in a Maryland county next to our nation's capital.[28–32] The story, demonstrating the personal and health care system implications of unmet oral health needs, appeared on the Metro page of the Washington Post, under the headline, "For Want of a Dentist: Prince George's Boy Dies After Bacteria from Tooth Spread to Brain". Due to structural health system barriers, 12-year old Deamonte Driver died of an untreated toothache when a routine $80 tooth extraction would have saved his life. His mother could not find a dentist who accepted Medicaid. She was not insured and also focused on an unsuccessful search for a dentist to treat his brother who had six decayed teeth and extreme pain. By the time Deamonte's own aching tooth received attention in an emergency room, the bacteria from his abscess had spread through his tooth and surrounding bone and entered his brain. Bacterial meningitis and septicemia are serious, life-threatening illnesses. At least 50 strains of bacteria may cause meningitis, but the main types are *Meningococcal His, Pneumococcal*, *Haemophilus influenza*e *type B*, *E. coli, Listeria, Salmonella, and Tuberculosis*. Early symptoms are typically high fever, vomiting, headache, and just feeling unwell.

In the case of Deamonte Driver, a quick oral examination under his upper lip would have allowed assessment of redness, swelling, abscess, and the source of severe pain. His preventable and untimely death, as well as the ultimate cost of his care in the emergency room at $250,000 after two operations and more than 6 weeks of hospital care, profoundly underscore the failure of American health policy to include oral health within medical health coverage. Ironically, Deamonte's mother was able to provide routine medical care and the required school immunizations for her children, but gaining access to the dental system consistently presented barriers for the Driver family.

At the time of Deamonte's death, fewer than 20% of Maryland's dentists were reported to accept Medicaid patients; reimbursement provided to dentists who saw Medicaid patients was low; and only a third of the state's Medicaid covered children received care.[33] These dire circumstances were known to state dental leaders, who, prior to 2007, developed multiple initiatives – surveillance, public and provider awareness, workforce enhancements, targeted oral health plans and more - to build the capacity to expand and strengthen dental services for vulnerable populations, especially for children. However, progress was slow. Deamonte's tragic death accelerated a rapid response by the Governor and the Secretary for Health, who charged a Dental Action Committee to develop recommendations for immediate action. Within a five-year period, Maryland experienced major improvements. Early wins included streamlining Medicaid dental services through a single vendor, increasing dental reimbursement rates to the 50th percentile, supporting a dental public health clinical infrastructure, routinely screening school children, training medical and dental providers to enhance their skills in providing preventive dental services, and developing a unified oral health message using health literacy principles to educate the public, providers, and policy makers.[33]

Deamonte's death elevated the need for extreme and swift action. However, policy efforts require continuous support and monitoring, and benefit from broad coalitions working with multiple sectors.[34] Needed policy efforts in Maryland continue to address other aspects of oral health care inequities, specifically for adults. The Governor formally signed legislation (effective January 2023) in Spring 2022, to fund an adult dental benefit in the Medical Assistance Program, and importantly included supplemental funds in the state budget to support an increase in Medicaid dental reimbursement rates. In addition, the Maryland legislature expanded Medicaid Postpartum Coverage to 12 months. This provides an opportunity to encourage integration of oral and obstetrics care.[35]

Tooth decay is one of the most common infections in childhood and remains second only to the common cold in terms of prevalence in children.[1,36] Also, at the state level we learned that Medicaid-eligible state numbers do not reflect how many people, like the Driver family, have little or no access to quality oral health care. Individuals with special needs face even more challenging health care inequities.[1,37,38] These, and related issues plead for the creation of national and state plans to achieve equity in oral healthcare for all Americans across the lifespan.[28–32]

The late Congressman Elijah Cummings (D, Maryland) reflections about oral health care during the early years after Deamonte Driver's death still resonate: "We all should work toward the day when oral health will no longer be an afterthought and is fully integrated with overall health care".[39]

Clarifying How We Categorize Oral Diseases

In the context of healthcare leadership, how the profession defines diseases and applies scientific evidence can lead to confusion and often apathy and has implications for health policy development and program interventions. We assert that this applies to the diagnosis, description, treatment, and oral health outcomes for the most common oral diseases, dental caries (tooth decay) and periodontal (gum) diseases.[6,7] ODC diseases and conditions and their impact are vast and complex and do not easily "fit" a specific category. Two strikingly different classifications or interpretations have been advanced by the dental profession for dental caries and periodontal disease: (1) Dental caries and periodontal disease are both non-communicable diseases and (2) Dental caries and periodontal disease are both communicable, infectious oral diseases. Communicable disease implies infection and transmissibility, whereas non-communicable disease (NCD) is the opposite. A closer look at these classifications provides insights to different health policy options and opportunities. The health equity challenges for these oral diseases and disorders, as well as others, in part resides in the confusion regarding risk, prevention, diagnosis, treatments, affordability, and health outcomes. Clarifying these issues can inform a more equitable approach to oral and general health.

In the first case, dental caries and periodontal diseases are linked to the four most widespread NCDs, ie, cardiovascular disease, cancer, diabetes, and chronic respiratory diseases. NCDs, also referred to as chronic diseases, tend to be of long duration. For example, analyses describe dental caries as unevenly distributed in populations with a strong socioeconomic gradient.[40–47] Social determinants of health are factors, such as housing, education, access to healthy foods and more, that affect health, well-being and quality of life. They contribute to the conditions where people live, work, play and age. Many dimensions of the unmet oral health needs reside within social determinants, especially poverty.[1,2,9,11,12,21,28–32] Epidemiologic studies illustrated that these dental diseases are not unlike other systemic conditions described as NCDs. The bundling of these diseases/conditions has been supported by considering what these conditions have in common, such as a combination of behavioral, physiological, environmental and genetic factors. Ninety-one percent of adults aged 20–64 years had dental caries and 27% had untreated tooth decay. Untreated tooth decay in the US is significantly higher for individuals with low incomes and for Hispanic, African Americans and American Indian populations. Periodontal (gum) disease is present in more than 60% of the US population.[1,2,7,28] Consequently, oral health has been increasingly promoted as a part of the NCD spectrum since the 2011 United Nations (UN) high-level meeting on NCDs.[40–47] The sharing of common risk factors and economic and social determinants of health lends itself to an integrated approach that crosses disease boundaries and benefits conditions clustered within groups of individuals. This is an excellent argument to integrate oral healthcare with primary care to address chronic infectious diseases and disorders. However, this approach alone does not address the second classification that these oral diseases are communicable, infectious diseases.

Scientific discoveries support the second case that dental caries and periodontal diseases are, in fact, communicable, infectious, transmitted diseases associated with specific microorganisms, environmental factors, and stage of life.[48–68] This knowledge suggests integration of oral health and primary care around key issues of education and clinical training in infection, inflammation, microbiology and virology, microbial genomics, vaccines, and other prevention strategies, and necessitates the active involvement of multiple health care professions and appropriate reimbursement for their services.

Of the infectious diseases that affect humans, tooth decay is the most prevalent and is caused by bacteria colonizing the tooth surfaces with a biofilm.[1,2,48–61,64–66] However, rather than being caused by an exogenous pathogen, tooth decay is due to an imbalance of the local oral biota.[59] The introduction of refined sugar and excessive carbohydrates, inherent in fast foods, and, thus, into society's food choices, tips the balance from oral health to disease and is initiated as early as infancy.[64]

Numerous studies into the natural history of the major tooth-infecting bacteria, the *mutans streptococci*, have already begun to contribute to the control or prevention of this infectious disease.[54–58,61] We now understand that strains of *mutans streptococci* are highly conserved within mothers and their children, suggesting vertical transmission of this organism.[48–51,54–58] Several studies demonstrate the transmission from mother or caregiver to infant is through saliva and shared eating utensils. The acquired bacteria from mother to infant is identical based upon molecular microbiological assays.[49,54–58] Pediatric primary care providers are usually the first health care providers to examine the oral cavity of an infant or young child and, therefore, need to recognize suspicious dental infectious lesions (eg, white discrete patches on tooth surfaces).[53–58] Recognizing tooth decay and understanding the epidemiology, pathogenesis, and treatment of oral infections should be shared amongst all primary health professionals including nurses, midwives, physicians (including obstetricians and pediatricians), physician assistants, and members of the dental profession as well as caregivers.[1,2,69–77]

Also of import, periodontitis is triggered by a specific group of aggressive bacteria and is the most common cause of tooth loss in adults.[7] Numerous scientific studies show that periodontitis is an infectious disease and is therefore also communicable.[62,63] The use of molecular genetic techniques has facilitated the demonstration that transmission of pathogenic periodontal microorganisms from parents to children, from children to children, and among spouses, occurs. The primary way that oral disease of the soft tissues surrounding each tooth can be transmitted person-to-person is through saliva (eg, billions of bacteria can be found in human saliva).

Tooth decay and periodontal diseases are major contributors to poor health outcomes, most directly to edentulism. In terms of severe oral health outcomes, the National Institute for Dental and Craniofacial Research (NIDCR), National Institutes of Health (NIH), found that about 10% of Americans between the ages of 50 to 64 are edentulous.[1,2,78,79] The Centers for Disease Control and Prevention (CDC) estimates that 13% of the Americans between the ages of 65 and 74 have no teeth, and that 26% of the Americans 75 and older have no teeth.[79,80] The number of healthy remaining teeth in our mouths may serve as a surrogate for optimal oral health care at any stage of the human lifespan. Lack of teeth compromises the ability to chew and swallow our food and limits our diets. Total tooth loss also curbs social interactions, the ability to speak and express oneself, and may be a barrier to employment.

Creating a more equitable health care system that integrates oral health requires including strategies that address both the communicable infectious attribute as well as the chronic, NCD, nature of these diseases. Health care practices and policies have tended to focus on the NCD category. The unintended consequence of this approach may have delayed the adoption of early interventions to prevent pathogen exposure and transmission. A combination of clinical primary care and population-based public health approaches is needed. Indeed, initiatives that include oral health in primary care and in public health programs are underway.[81] Recognition of both communicable and non-communicable attributes of these oral diseases may accelerate the adoption and scaling of these initiatives. It also could enlighten a needed review of the current educational preparation of the health care workforce, oral-related health care services and reimbursement practices, and of policy makers' understanding of these attributes.[1,2,69–77] The scientific evidence provides an optimistic foundation for new and enhanced oral health policies to be reviewed, crafted, and implemented.

Learning from the Human Oral Microbiome

The over 700 different species of bacteria and other microorganisms, including viruses, fungi and protozoa, that inhabit our mouths are referred to as the human oral microbiome. This community of diverse microorganisms is found in the

form of a biofilm on the hard tissues of the teeth and soft tissues surrounding the teeth and the oral mucosa of the mouth. The human oral microbiome plays a key role protecting the oral cavity and preventing disease development. It is also a rich resource for understanding the role of mouth in oral and general health and disease, and is critical for informing the development of diagnostics, therapeutics and for the surveillance of disease and health states.[67,68,82] After the gut, the oral cavity has the second largest microbiome. Due to the ease of accessing the mouth and saliva, an informative biologic fluid, it has become the most studied microbiome.

Microbes are introduced into the oral cavity of the infant during childbirth and beyond. While the womb of the human fetus is usually sterile, studies have reported intrauterine environment colonization by oral microorganisms in up to 70% of the pregnant women.[83,84] Usually, the newborn's oral cavity is sterile at birth, but it is regularly inoculated with microorganisms from the first feeding onward. The first common microorganism found in the infant's mouth is derived from saliva, through passive transfer from mother to infant, and from microorganisms present in water, milk, and the environment. Shortly after birth, initial colonization begins with *streptococcus salivarius* followed by *Streptococcus, Lactobacillus, Actinomyces, Neisseria* and *Veillonella*. As teeth erupt, more tooth surfaces become available for colonization of these microorganisms.

Mutans streptococci, particularly *Streptococcus mutans*, are the main bacterial species that initiate human dental caries; animal and human dental caries are infectious and transmissible disease first demonstrated by Keyes and more recently by Aas, Albander, Ashimoto, Carlsson, Caufield, Costerton, Dewhirst, and others.[48–51,54–67] Curiously, they are not found in infants, but become evident as teeth erupt into the oral cavity at 6 months and thereafter. The peak detection phase is during adolescence within the 1000 bacterial species that exist within the human oral cavity. With aging, when many or all teeth may be lost, the flora becomes like that of a child before tooth eruption. Scientific studies have advanced our understanding of diversity within strains of bacteria such as lactobacilli associated with severe early childhood tooth decay. Today, precise knowledge of the genotype for the *lactobacillus strain* associated with oral infection is known.[67,68,82]

In addition to being the initiation point of digestion, the oral microbiome is crucial in maintaining oral as well as systemic health. Studies of the oral microbiome facilitate our understanding of metabolic and functional alterations that occur with disease and identify molecular signatures for diagnostic and therapeutic targeted therapies. New genomic technologies, such as next-generation sequencing and bioinformatics, have accelerated studies of the microbiome.[67,68,82] Oral and systemic diseases associated with the oral microbiome have been identified, illuminating the potential predictive relationship between the microbiota in the mouth and other diseases. Beyond dental caries, periodontal diseases and oral cancer, associations have been found for colorectal cancer, pancreatic cancer and inflammatory bowel syndrome. These findings suggest that the oral cavity offers significant potential for disease diagnosis and rapid point-of-care test development.

The evolving story of our understanding of the oral microbiome provides a unique example of how science continues to inform overall health and disease. Incorporating and reimbursing for emerging tests and therapies as an essential part of the healthcare clinical armamentarium would enrich the overall healthcare system and is of great value for primary care professional education and for the integration of primary care and oral healthcare.[53]

Monitoring Access, Costs and Health Outcomes

The US health care system has not met the full range of societal needs for delivering quality, integrated and comprehensive care for all Americans throughout the lifespan, or in managing health care spending.[10–14,28–32] Only 70% of the population has access to care. Costs continue to increase. US health care including dental care is the most expensive in the world compared with other high-income countries.[10,13,14] While utilization of medical care between the US and other high-income countries is similar, major drivers of the difference in spending in the US are due to administrative costs and prices of labor and goods, such as pharmaceuticals.[85] Even with efforts to curb and decrease spending, US health and dental care expenditures have continued to grow.[10,13,14] The US personal health care expenditures, which include dental care expenditures, have grown 31% between 2009 and 2019. In 2019, personal health care expenditures totaled $3.2 billion, with expenditures for dental services representing a small but important percent

(4.5%).[86] Studies continue to reveal associations between poor oral health and chronic conditions and access to preventive and conservative care is associated with better health outcomes.[1,2,87–90]

It is estimated that healthcare costs, not including the costs of the current pandemic, will continue to grow at 5.5% per year, reaching $6 trillion by 2027.[86] One-third of the total population are not living longer, are not healthier, and are not receiving the best care for dollars spent.[10] Significant challenges persist for city, county, and state health programs, including Medicaid. Federal programs such as the Children's Health Insurance Program (CHIP), Federally Qualified Health Centers (FQHCs) and Medicare face serious problems with access, cost, and health outcomes.[10]

A careful review of healthcare expenditures, including dental care expenditures, will identify factors, such as use patterns, provider types, patient characteristics and services delivered, that can inform healthcare design and monitoring. This is a critical exercise for both private and public payer perspectives. It is anticipated that Medicaid enrollment will double or even triple, and given our demographic trends, demand for Medicare services will similarly increase. To complement previous studies of health expenditures, additional studies to address gender diversity and ethnicity in the study populations are needed.

The inclusion of dental services in public and private health plans provides prospects for enhanced health care, especially for low-income individuals. The passage of the Patient Protection and Affordable Care Act (ACA) in 2010 provided major health care reforms and included pediatric dental services as one of the 10 essential benefits in its exchange plans, opening dental coverage for children beyond those from low-income families. A comparable enhancement did not occur for adults. However, the ACA included the opportunity for adults to obtain dental benefits through the insurance exchanges. By 2010 8.3 million adults gained dental benefits beyond emergency care.[91] The challenge remains that low Medicaid provider reimbursement rates are a barrier to provider participation in Medicaid and thus limit the number of providers available to serve Medicaid eligible adults. Only 39% of the dentists nationwide accept Medicaid and or Children's Health Insurance Program (CHIP). In addition to inadequate provider availability, individual barriers exist, such as challenges with transportation, costs of copayments, work and child care arrangements, and lack of awareness of dental benefits. As more low-income adults shift from dental coverage to Medicaid, there is increasing demand for Medicaid services, yet dental coverage is inadequate. In 2019, while nearly all states offer some dental benefit and 36 states and DC cover services beyond emergency care, only 19 covered extensive dental services.[92] However, now more states are adding or increasing adult Medicaid dental benefits. California has led in this area and significantly increased reimbursement to dentists—resulting in a substantial increase in the number of dentists willing to see Medicaid patients. The implementation of the requirement that FQHCs provide dental services has also been helpful.

Support for the inclusion of dental services in Medicare continues to receive increasing support from multiple medical, health care, patient advocacy and dental organizations. The Community Statement on Medicare Coverage for Medically Necessary Oral and Dental Health Therapies highlights the significant health impact and health care savings that would result from covering medically necessary oral and dental health care, and concludes: "Given the significant potential to improve health outcomes and reduce program costs, we urge Congress and the Administration to explore options for extending such evidence-based coverage for all Medicare beneficiaries".[93]

There are multiple factors addressing national healthcare; three major factors include (1) access (for what percentage of the total population?), (2) affordability (of healthcare?) and (3) health outcomes (following diagnosis and therapy?). Additional factors include acceptability (are the facilities, services, and providers culturally competent and culturally humble?) and availability (are the needed services geographically close and accessible by public transportation?). Consideration also should be given to the paradigm shift from "volume-based" to "performance-based (value-based)" reimbursements from third-party payers. This shift allows us to review issues of access and cost containment. It also allows a review of providing "low-cost, high-value" healthcare that aligns with the proposed six-domain framework ("safe, effective, patient-centered, timely, efficient, and equitable") articulated by the Institute of Medicine in 2001.[94] The "triple aim" of the Institute for Healthcare Improvement gained popularity over the past decade supporting the movement from volume to value-based care.[95] Attention was focused on "improving the patient experience of care (including quality and satisfaction); improving the health of populations; and reducing the per capita cost of health care".[95]

Recently, given the impact of the pandemic and related events this concept has been expanded to the "quadruple aim" (addressing clinician burnout) and to the quintuple aim (advancing health equity).[96] These aims provide additional

support for expanding the primary care workforce. The inclusion of dentists who are additionally trained in primary care could provide a significant resource to the primary care workforce. In addition, the inclusion of preventive dental services provided by physicians, nurse practitioners and others provide another opportunity to expand the primary care workforce. The Primary Care Collaborative's 2021 report documents examples of the broad spectrum of oral health and primary care innovations across the life course and their alignment with the shared principles of primary care.[81,97]

Our health care systems have continued to incorporate emerging technologies and data analytic and computational advances, adding additional considerations to access, costs and health outcomes. The pandemic has seen an exponential rise in the use of telemedicine and teledentistry.[98,99] These technologies, and others, are transforming healthcare delivery. At the same time, there is limited information of cost–benefit data and use of emerging technology by providers and patients. An estimated 25–30% of the total healthcare costs are attributed to uncontrolled use of expensive technology and ancillary testing.[100] Artificial Intelligence (AI), the use of computer systems to simulate human decision-making, is already in use for dental management for both financing and care systems. The Food and Drug Administration has approved the use of AI in the diagnoses of dental caries and periodontal disease. AI has the potential to add greater efficiencies and quantification of oral conditions with potential for enhanced patient education and engagement. As AI applications and tools become more ubiquitous, providers will require formal training in the understanding and appropriate use of AI for clinical decision-making and careful review of the AI algorithms for bias and their respective impact on care services is warranted.[100] The focus on patient benefit is a critical factor in assessing and applying new technologies.

Reducing Oral Disease Risks and Enhancing Health

The separation of dentistry from medicine has a long history, although during the last 100 years, science has been a significant force that translated into better oral health for more people – biomimetics, local anesthetics, imaging, and an array of digital technologies.[3–8] The abundance of new scientific knowledge and technology has unveiled insights about the intricate connections within our bodies and has stimulated new diagnostics and therapeutics. This provides further evidence for the need to close the "historical divide between the dental profession and the evidence-based methods of general medicine".[101] The rising prevalence of oral diseases nationally and globally reveals the urgency to act and accelerate the integration of oral and general healthcare.[1,2,29–31]

The global overview provides the context for the burden of oral diseases in related to systemic diseases: "untreated dental caries in permanent teeth was the most prevalent health condition in 2010, affecting 35% of the global population, or 2.4 billion people worldwide;" "severe periodontitis was the sixth most prevalent health condition;" and "lip and oral cavity cancers are among the top 15 most common cancers worldwide".[40,43] In the US, Surgeon General David Satcher prioritized this issue in his 2000 landmark report, "Oral Health in America". He called oral diseases and conditions "a silent epidemic promoting the onset of life-threatening disease that is responsible for the deaths of millions of Americans each year".[1] Following this report, studies contributed additional associations between periodontitis and other serious health conditions and revealed that periodontitis is triggered by a specific group of aggressive bacteria, is transmitted through saliva from person-to-person, and is considered the most common cause of tooth loss in adults.[1,7,28,102–105] The 2020 NIH report, "Oral Health in America: Advances and Challenges", provided updates from 20 years of science. While substantive achievements were identified, the report highlighted remaining challenges that require attention: "1 in 5 low-income adults report(ing) they have not visited a dentist within five years or more or have never visited a dentist".[2]

Also, public insurance programs with dental benefits for adults and seniors continue to be limited. Vulnerable populations, such as those living in rural areas, individuals residing in long-term care or correctional settings, and those with special health care needs, face even greater challenges in care access.

Over the past three decades, there has been considerably more dental, nursing and medical school interprofessional education collaborations. This is good news. We are witnessing the integration of oral health content into nursing education, family medicine and pediatric residency training programs, and into primary care.[69–77] In addition, educational efforts focused on common risk factors and conditions have been offered, such as those directed at smoking cessation, obesity prevention and diabetes management. The pandemic stimulated further progress. During 2020–2022, dental school faculty and students have successfully participated in the COVID-19 vaccine immunization clinics. Beyond

contributions to emergency response needs, dental practice acts continue to expand the dentist's capacity to contribute to primary care. In 2019, Oregon became the first state to permit dentists offer any vaccination to patients, and a growing number of states are following suit.[106–108]

Opportunities for integrating oral health into medical care and primary care services into dental care are revealed in a review of the pattern of dental and medical visits in a year. In 2018, 8.6% (28.2M) had a dental visit only and 34.4% (112.3M) had a medical visit only, while 37.1% (121.2M) had both.[109] An integrated healthcare system and environment would take advantage of these population trends and embed general health screenings, such as for high blood pressure or elevated blood sugar, and treatment compliance checks in both dental and medical clinical settings. Of relevance, the Primary Care Collaborative's "Innovations in Oral Health and Primary Care Integration" report provides a substantive overview of ongoing integration initiatives organized by the shared principles of primary care. These examples demonstrate the diversity of approaches that can be used and highlight the range of service settings and workforce models being tested, including expansion of practice settings for dental hygienists in medical care clinics. Recognizing that the initiatives are an initial start, the report calls for specific policy actions to "expand oral health coverage and access;" "align oral health and primary care with new payment models;" and "grow the oral health workforce" in order to create a more holistic approach to health care and one that addresses health equity.[81]

The pandemic has demonstrated the critical need to advance health equity, now referred to as the "quintuple aim" supporting the movement from volume-based care to value-based care.[91] Experts also predict that an emphasis on disease prevention and innovations in case management and care delivery that are patient-centered could ultimately lower costs.[11,13,14,110–112] Findings from a number of studies examining patients in public and private insurance systems have demonstrated healthcare cost savings and improved health outcomes by inclusion of preventive dental care (tooth cleaning) and conservative periodontal treatment services for persons with diabetes.[87–90]

The future of integrated oral and primary care healthcare will continue to evolve, increasing the focus on prevention, deploying tools to enhance precision and personalized care, incorporating new technologies such as telemedicine and smartphone communications, and facilitating easier access to care.[72,112–124] Oral healthcare integrated into primary care with teams consisting of health professionals with expertise in pediatrics, geriatrics, internal medicine, oral health and disease, family medicine, primary care, nursing, behavioral sciences, and social service will increasingly provide healthy and brighter smiles.[1,2,28,69–77]

Accelerating Oral and Overall Health Promotion

The rapidly changing demographics of our population inform the urgency of these actions and increase the demand for oral health services. National health spending is anticipated to reach $6.2 trillion by 2028.[125] Population projections for 2060 estimate that Americans aged 65 and older are becoming more racially and ethnically diverse and will comprise almost a quarter of the total population (23%).[125,126] The growth in older adults translates into higher projected enrollment in Medicare. Further, the national and global rise in the prevalence and incidence of chronic infectious diseases will increase oral diseases, such as periodontal disease and root caries, thereby requiring seamless integration and care coordination of interprofessional oral and general health services in clinical, community and long-term care facilities. The pioneering studies by Marjorie Jeffcoat et al and more recently Ira Lamster et al clearly established that preventive oral health care decreases the costs for patients with type 2 diabetes and several other chronic diseases.[87–90] Ideally, our healthcare systems and policy makers must embrace and support a proactive and systems-oriented approach to disease prevention and health promotion, beginning with perinatal health and continuing throughout life and healthcare transitions.

Several opportunities to reduce unmet oral health needs are suggested based upon the scientific foundations discovered since the pioneering investigations of Paul Keyes in 1960:[48]

- Design and implement national, state, and local comprehensive evidence-based oral disease prevention and health promotion strategies. These strategies should be included in ongoing annual evaluations that measure access, cost affordability, diagnosis and treatment, and health outcomes including optimum oral health. Existing primary care oral and general health promotion evidence-based interventions can inform a toolkit guide for health care providers.

- Commit to national, state, and local priorities to integrate oral health and general health education and training and for policy makers to promote alternative workforce models. Enhanced oral health and primary care education and training of health care providers will extend the available workforce, facilitate new models of care, and address oral health equity by enhancing access to primary care across the lifespan. Creating a new residency program in oral primary care while increasing opportunities within existing schools of dentistry would further integration.
- Include comprehensive dental benefits into existing public and private insurance programs and support effective provider reimbursement levels. Specific attention should be given to low-income individuals, pregnant women and their infants, individuals with disabilities and the elderly. Quality dental care should be a mandatory component of pregnancy-related Medicaid services for the mother and infant; and adult dental care should be an essential benefit for Medicaid and Medicare eligible individuals.
- Expand and secure oral health surveillance activity and capacity at the national, state, and local levels to document and monitor health disparities, evolving oral health problems, and the impact of ongoing disease prevention and health promotion strategies/intervention.

Public policy strategies for addressing oral health inequities can benefit from a multi-stakeholder approach.[127] Effective and proven scientific and social mechanisms can be coordinated in policy development frameworks to advance holistic health, including oral health. Leaders from public and private sectors, especially those in healthcare and education, are well positioned to change the inadequate paradigm. The nation's healthcare system will be more aligned with the foundational elements of the Triple Aim, especially the better health outcomes element, when it responds to the consistent call and critical need for leadership and collaboration across all health professions, public and private sectors, and patient and community advocates.[1,2,128]

National guidelines that address oral health must be defined. If these are implemented, they will increase the accessibility to oral health for older adults. In parallel with this, revisions of existing older adult insurance schemes (eg, the inclusion of routine oral healthcare in the US Medicare and Medicaid programs) would promote the maintenance of a functional dentition that is pain-free and conducive to general health for a lifetime.

Conclusion

The most recent experience with SARS-CoV-2 and strategies to limit its spread required large-scale policy interventions by government and private sector leaders, and had a major impact on medical and dental healthcare. The variance in federal, state, and local policies regarding protections against COVID-19, along with emerging science, led to confusion and diffuse adoption of preventive behaviors. The early stages of previous epidemics have followed similar stages of inconsistencies across individual, community, and social norms, including policy direction for overall health and wellbeing. Beyond crisis-level policy responses, the US continues to examine its values and practices of health care, coverage, and expenditures. Identified as a "silent epidemic", oral health continues to be exempted from both urgent and longer-term health policy advancements. This exclusion exacerbates unmet oral health needs and untreated disease. Promising administrative directives for Medicare coverage for oral health are currently under review and will benefit from advocacy from health care leaders across multiple settings. The current and rapidly emerging science base related to oral, dental and craniofacial health offers healthcare leaders the opportunity to create a holistic healthcare system, one that integrates oral health for all people across the lifespan. Oral health in all health policies is an imperative for the future.

Acknowledgments

The authors wish to thank the Santa Fe Group for their continued discussions of advocacy to improve the general and oral healthcare for all Americans. The authors also thank Ms Carson Peters, MPH, for her careful read of the final draft and for preparing the manuscript to meet journal publication requirements.

Disclosure

Ralph Fuccillo reports personal fees from Overjet, Inc, outside the submitted work. The authors report no other conflicts of interest in this work.

References

1. U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research. *Oral Health in America: A Report of the Surgeon General*. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research; 2000.
2. U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research. *Oral Health in America: Advances and Challenges*. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research; 2021.
3. Pihlstrom BL. Highlights of America's scientific contributions to dentistry: 150 years and still counting. *J Am Dent Assoc*. 2009;140(Suppl 1):4S–6S. doi:10.14219/jada.archive.2009.0352
4. Gutmann JL. The evolution of America's scientific advancements in dentistry in the past 150 years. *J Am Dent Assoc*. 2009;140(Suppl 1):8S–15S. doi:10.14219/jada.archive.2009.0354
5. Snead ML, Slavkin HC. Science is the fuel for the engine of technology and clinical practice. *J Am Dent Assoc*. 2009;140(Suppl 1):17S–24S. doi:10.14219/jada.archive.2009.0351
6. Zero DT, Fontana M, Martínez-Mier EA, et al. The biology, prevention, diagnosis and treatment of dental caries: scientific advances in the United States. *J Am Dent Assoc*. 2009;140(Suppl 1):25S–34S. doi:10.14219/jada.archive.2009.0355
7. Armitage GC, Robertson PB. The biology, prevention, diagnosis and treatment of periodontal diseases: scientific advances in the United States. *J Am Dent Assoc*. 2009;140(Suppl 1):36S–43S. doi:10.14219/jada.archive.2009.0356
8. Garcia I, Tabak LA. A view of the future: dentistry and oral health in America. *J Am Dent Assoc*. 2009;140(Suppl1):44S–48S. doi:10.14219/jada.archive.2009.0357
9. Satcher D. *My Quest for Health Equity: Notes on Learning While Leading*. Baltimore: Johns Hopkins University Press; 2020. Available from: https://muse.jhu.edu/book/76605. Accessed September 24, 2022.
10. Kronfeld JJ, Kronfeld M. *Healthcare Reform in America*. 2nd ed. Santa Barbara: ABC-CLIO; 2015.
11. United Health Foundation. Health disparities report; 2021. Available from: http://www.americashealthrankings.org/learn/reports/2021-disparities-report/introduction. Accessed August, 2022.
12. Edelman P. *So Rich, so Poor: Why It's so Hard to End Poverty in America*. New York: The New Press; 2012.
13. Kamal R, Cox C, McDermott D, Ramirez M, Sawyer B. U.S. health system is performing better, though still lagging other countries. Peterson-Kaiser Health System Tracker; 2017. Available from: https://www.healthsystemtracker.org/brief/u-shealth-system-is-performing-better-though-still-lagging-behind-othercountries/. Accessed May/June, 2022.
14. Organisation for Economic Co-Operation and Development. Key facts about spending by disease in OECD countries (Australia, Canada, Czech Republic, England, Finland, France, Germany, Hungary, Israel, Japan, Korea, the Netherlands, Slovenia, Sweden, Switzerland, and the United States). Available from: https://stats.oecd.org/. Accessed July, 2022.
15. National Academies of Sciences, Engineering, and Medicine. *Implementing High-Quality Primary Care: Rebuilding the Foundation of Health Care*. Washington, DC: The National Academies Press; 2021. doi:10.17226/25983
16. LaVeist TA, Gaskin D, Richard P. Economic burden of racial health inequalities in the United States. *Int J Health Serv*. 2011;41(2):231–238. doi:10.2190/HS.41.2http://baywood.com
17. U.S. Department of Health and Human Services. Health equity in healthy people 2030. Healthy People; 2030. Available from: https://health.gov/healthypeople/priority-areas/health-equity-healthy-people-2030. Accessed September 24, 2022.
18. U.S. Department of Health and Human Services, Centers for Medicaid and Medicare Services (CMS). CMS strategic plan pillar: health equity. Available from: https://www.cms.gov/files/document/health-equity-fact-sheet.pdf. Accessed September 24, 2022.
19. D'Souza RN, Collins FS, Murthy VH. Oral health for all – realizing the promise of science. *N Engl J Med*. 2022;386(9):809–811. PMID: 35213102. doi:10.1056/NEJMp2118478
20. Seirawan H, Faust S, Mulligan R. The impact of oral health on the academic performance of disadvantaged children. *Am J Public Health*. 2012;102(9):1729–1734. doi:10.2105/AJPH.2011.300478
21. Lewis C, Stout J. Toothache in US children. *Arch Pediatr Adolesc Med*. 2010;164(11):1059–1063. doi:10.1001/archpediatrics.2010.206
22. Jackson SL, Vann WF Jr, Kotch JB, Pahel BT, Lee JY. Impact of poor oral health on children's school attendance and performance. *Am J Public Health*. 2011;101(10):1900–1906. doi:10.2105/AJPH.2010.200915
23. Naavaal S, Kelekar U. School hours lost due to acute/unplanned dental care. *Health Behav Policy Rev*. 2018;5(2):66–73. doi:10.14485/HBPR.5.2.7
24. Krisdapong S, Prasertsom P, Rattanarangsima K, Sheiham A. School absence due to toothache associated with sociodemographic factors, dental caries status, and oral health-related quality of life in 12- and 15-year-old Thai children. *J Public Health Dent*. 2013;73(4):321–328. doi:10.1111/jphd.12030
25. Loveless B. Chronic absenteeism: perils and possibilities. Education corner. Available from: Https://www.educationcorner.com/chronic-absenteeism.html. Accessed September 24, 2022.
26. Pourat N, Nicholson G. *Unaffordable Dental Care is Linked to Frequent School Absences*. Los Angeles, CA: UCLA Center for Health Policy Research; 2009. Available from: https://pubmed.ncbi.nlm.nih.gov/19960616/. Accessed September 1, 2023.
27. Dudovitz RN, Valiente JE, Espinosa G, et al. A school-based public health model to reduce oral health disparities. *J Public Health Dent*. 2018;78:9–16. doi:10.1111/jphd.12216
28. Treadwell HM, Evans CA. *Oral Health in America: Removing the Stain of Disparity*. Washington, DC: American Public Health Association Press; 2019.
29. Otto M. *Teeth: The Story of Beauty, Inequality, and the Struggle for Oral Health in America*. New York: The New Press; 2017.

30. Institute of Medicine. *Advancing Oral Health in America*. Washington, DC: The National Academies Press; 2011.
31. Institute of Medicine and National Research Council. *Improving Access to Oral Health Care for Vulnerable and Underserved Populations*. Washington, DC: The National Academies Press; 2011.
32. Moeller J, Starkel R, Quiñonez C, Vujicic M. Income inequality in the United States and its potential effect on oral health. *J Am Dent Assoc*. 2017;148(6):361–368. doi:10.1016/j.adaj.2017.02.052
33. Thuku NM, Carulli K, Costello S, Goodman HS. Breaking the cycle in Maryland: oral health policy change in the face of tragedy. *J Public Health Dent*. 2012;72:S7–S13. doi:10.111/j.1752-7325.2012.00328.x
34. Tinanoff N, Goodman H, Klein B. The legacy of deamonte driver. *J Public Health Dent*. 2022;82:251–252. doi:10.1111/jphd.12535
35. Maryland Dental Action Coalition. Adult dental benefit in Medicaid and Medicaid postpartum dental coverage. Available from: https://www.mdac.us/. Accessed September 20, 2022.
36. Centers for Disease Control and Prevention. *Oral Health Surveillance Report: Trends in Dental Caries and Sealants, Tooth Retention, and Edentulism, United States, 1999–2004 to 2011–2016*. Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services; 2019. Available from: https://www.cdc.gov/oralhealth/publications/OHSR-2019-index.html. Accessed February 21, 2023.
37. May PB, Hood H, Holder M, Rader R. The five essential concepts of developmental medicine: a medical paradigm for persons with developmental disabilities. *HELEN*. 2022;4:16–23.
38. Nadershahi N. A message from the dental education community. *HELEN*. 2022;1:42–43.
39. Cummings E. Fulfilling the legacy of a 12-year-old boy. *J Public Health Dent*. 2012;72:S5–S6. doi:10.1111/j.1752-7325.2011.00300.x
40. Peres MA, Macpherson LMD, Weyant RJ, et al. Oral diseases: a global public health challenge [published correction appears in Lancet. 2019 Sep 21;394(10203):1010]. *Lancet*. 2019;394(10194):249–260. doi:10.1016/S0140-6736(19)31146-8
41. Dörfer C, Benz C, Aida J, Campard G. The relationship of oral health with general health and NCDs: a brief review. *Int Dent J*. 2017;67 (Suppl2):14–18. doi:10.1111/idj.12360
42. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. *Bull World Health Organ*. 2005;83(9):661–669.
43. Watt RG, Daly B, Allison P, et al. Ending the neglect of global oral health: time for radical action. *Lancet*. 2019;394(10194):261–272. doi:10.1016/S0140-6736(19)31133-X
44. Kassebaum NJ, Smith AGC, Bernabé E, et al. Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990–2015: a systematic analysis for the global burden of diseases, injuries, and risk factors. *J Dent Res*. 2017;96 (4):380–387. doi:10.1177/0022034517693566
45. Balaji SM, Seeberger GK, Hennedige O. Burden of oral diseases and noncommunicable diseases: an Asia-pacific perspective. *Indian J Dent Res*. 2018;29(6):820–829. doi:10.4103/ijdr.IJDR_812_18
46. Bennett JE, Stevens GA, Mathers CD; NCD Countdown 2030 collaborators. NCD countdown 2030: worldwide trends in non-communicable disease mortality and progress towards sustainable development goal target 3.4. *Lancet*. 2018;392(10152):1072–1088. doi:10.1016/S0140-6736(18)31992-5
47. Wolf TG, Cagetti MG, Fisher J-M, Seeberger GK, Campus G. Non-communicable diseases and oral health: an overview. *Front Oral Health*. 2021;2:725460. doi:10.3389/froh.2021.725460
48. Keyes PH. The infectious and transmissible nature of experimental dental caries. Findings and implications. *Arch Oral Biol*. 1960;1:304–320. doi:10.1016/0003-9969(60)90091-1
49. Balakrishnan M, Simmonds RS, Tagg JR. Dental caries is a preventable infectious disease. *Aust Dent J*. 2000;45(4):235–245. doi:10.1111/j.1834-7819.2000.tb00257.x
50. Caufield PW, Li Y, Dasanayake A, Saxena D. Diversity of lactobacilli in the oral cavities of young women with dental caries. *Caries Res*. 2007;41(1):2–8. doi:10.1159/000096099
51. Caufield PW, Li Y, Dasanayake A. Dental caries: an infectious and transmissible disease. *Compend Contin Educ Dent*. 2005;26(5 Suppl 1):10–16.
52. Kanasi E *Molecular Analysis of the Oral Microbiota of Dental Diseases*. [Doctoral dissertation]. Umea, Sweden: Umea University; 2008.
53. Kanasi E, Johansson I, Kressin NR, Nunn ME, Kent R Jr. Microbial risk markers for childhood caries in pediatricians' offices. *J Dent Res*. 2010;89(4):378–383. doi:10.1177/0022034509360010
54. Caufield PW, Cutter GR, Dasanayake AP. Initial acquisition of mutans streptococci by infants: evidence for a discrete window of infectivity. *J Dent Res*. 1993;72(1):37–45. doi:10.1177/00220345930720010501
55. Li Y, Caufield PW, Dasanayake AP, Wiener HW, Vermund SH. Mode of delivery and other maternal factors influence the acquisition of Streptococcus mutans in infants. *J Dent Res*. 2005;84(9):806–811. doi:10.1177/154405910508400905
56. Zhan L, Tan S, Den Besten P, Featherstone JD, Hoover CI. Factors related to maternal transmission of mutans streptococci in high-risk children-pilot study. *Pediatr Dent*. 2012;34(4):e86–e91.
57. Slayton RL. Reducing mutans streptococci levels in caregivers may reduce transmission to their children and lead to reduced caries prevalence. *J Evid Based Dent Pract*. 2011;11(1):27–28. doi:10.1016/j.jebdp.2010.11.014
58. Klein MI, Flório FM, Pereira AC, Höfling JF, Gonçalves RB. Longitudinal study of transmission, diversity, and stability of Streptococcus mutans and Streptococcus sobrinus genotypes in Brazilian nursery children. *J Clin Microbiol*. 2004;42(10):4620–4626. doi:10.1128/JCM.42.10.4620-4626.2004
59. Gaengler P, Markovic L, Norden D, Jordan RA. New insights in understanding dental caries and periodontal disease: the avalanche model. *Health*. 2009;1(4):263–268. doi:10.4236/health.2009.14042
60. Aas JA, Paster BJ, Stokes LN, Olsen I, Dewhirst FE. Defining the normal bacterial flora of the oral cavity. *J Clin Microbiol*. 2005;43 (11):5721–5732. doi:10.1128/JCM.43.11.5721-5732.2005
61. Aas JA, Griffen AL, Dardis SR, et al. Bacteria of dental caries in primary and permanent teeth in children and young adults. *J Clin Microbiol*. 2008;46(4):1407–1417. doi:10.1128/JCM.01410-07
62. Albandar JM. Global risk factors and risk indicators for periodontal diseases. *Periodontol*. 2000;29:177–206. doi:10.1034/j.1600-0757.2002.290109.x

63. Ashimoto A, Chen C, Bakker I, Slots J. Polymerase chain reaction detection of 8 putative periodontal pathogens in subgingival plaque of gingivitis and advanced periodontitis lesions. *Oral Microbiol Immunol*. 1996;11(4):266–273. doi:10.1111/j.1399-302x.1996.tb00180.x
64. Carlsson J, Johansson T. Sugar and the production of bacteria in the human mouth. *Caries Res*. 1973;7(4):273–282. doi:10.1159/000259851
65. Carlsson J, Gothefors L. Transmission of Lactobacillus jensenii and Lactobacillus acidophilus from mother to child at time of delivery. *J Clin Microbiol*. 1975;1(2):124–128. doi:10.1128/jcm.1.2.124-128.1975
66. Costerton JW, Stewart PS, Greenberg EP. Bacterial biofilms: a common cause of persistent infections. *Science*. 1999;284(5418):1318–1322. doi:10.1126/science.284.5418.1318
67. Dewhirst FE, Chen T, Izard J, et al. The human oral microbiome. *J Bacteriol*. 2010;192(19):5002–5017. doi:10.1128/JB.00542-10
68. Chen T, Yu WH, Izard J, Baranova OV, Lakshmanan A, Dewhirst FE. The human oral microbiome database: a web accessible resource for investigating oral microbe taxonomic and genomic information. *Database*. 2010;2010:baq013. doi:10.1093/database/baq013
69. U.S. Department of Health and Human Services (DHHS), Health Resources and Services Administration (HRSA). *Integration of Oral Health and Primary Care Practice (IOHPCP)*. Washington, DC: DHHS HRSA; 2014.
70. Harvard School of Dental Medicine Initiative. Integrating oral health and medicine. Available from: https://oralhealth.hsdm.harvard.edu/. Accessed July, 2022.
71. Donoff B, McDonough JE, Riedy CA. Integrating oral and general health care. *N Engl J Med*. 2014;371(24):2247–2249. doi:10.1056/NEJMp1410824
72. Slavkin HC. Societal needs and the role of health care in shaping the future of dentistry in the 21st century. *CDA J*. 2020;48(3):145–155.
73. Spielman AI, Fulmer T, Eisenberg ES, Alfano MC. Dentistry, nursing, and medicine: a comparison of core competencies. *J Dent Educ*. 2005;69(11):1257–1271. doi:10.1002/j.0022-0337.2005.69.11.tb04025.x
74. Dolce MC, Haber J, Savageau JA, Hartnett E, Riedy CA. Integrating oral health curricula into nurse practitioner graduate programs: results of a US survey. *J Am Assoc Nurse Pract*. 2018;30(11):638–647. doi:10.1097/JXX.0000000000000079
75. Haber J, Hartnett E, Allen K, et al. Putting the mouth back in the head: HEENT to HEENOT. *Am J Public Health*. 2015;105(3):437–441. doi:10.2105/AJPH.2014.302495
76. Silk H, King R, Bennett IM, Chessman AW, Savageau JA. Assessing oral health curriculum in US family medicine residency programs: a CERA study. *Fam Med*. 2012;44(10):719–722.
77. Dwiel K, Hesketh MA, Alpert JL, et al. The impact of oral health training for primary care clinicians: a systematic review. *Fam Med*. 2019;51(3):251–261. doi:10.22454/FamMed.2019.232634
78. Centers for Disease Control and Prevention, National Center for Health Statistics. Oral and dental health. Available from: https://www.cdc.gov/nchs/fastats/dental.htm. Accessed July, 2022.
79. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. QuickStats: prevalence of edentulism in adults aged >65 years, by age group and race/Hispanic origin - national health and nutrition examination Survey, 2011–2014; 2017. Available from: https://www.cdc.gov/mmwr/volumes/66/wr/mm6603a12.htm. Accessed July, 2022.
80. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report. Total tooth loss among persons aged greater than or equal to 65 years - selected states. *MMWR*. 1999;48(10):206–210.
81. The Primary Care Collaborative. Innovations in oral health and primary care integration: alignment with the shared principles of primary care Innovations in Oral Health and Primary Care Integration. 2021. Available from: https://www.pcpcc.org/resource/innovations-oral-health-and-primary-care-integration-alignment-shared-principles. Accessed September 24, 2022.
82. Deo PN, Deshmukh R. Oral microbiome: unveiling the fundamentals. *J Oral Maxillofac Pathol*. 2019;23(1):122–128. doi:10.4103/jomfp.JOMFP_304_18
83. Hill GB. Preterm birth: associations with genital and possibly oral microflora. *Ann Periodontol*. 1998;3(1):222–232. doi:10.1902/annals.1998.3.1.222
84. Bearfield C, Davenport ES, Sivapathasundaram V, Allaker RP. Possible association between amniotic fluid micro-organism infection and microflora in the mouth. *BJOG*. 2002;109(5):527–533. doi:10.1111/j.1471-0528.2002.01349.x
85. Papanicolas I, Woskie LR, Jha AK. Health care spending in the United States and other high-income countries [published correction appears in JAMA. 2018 May 1;319(17):1824]. *JAMA*. 2018;319(10):1024–1039. doi:10.1001/jama.2018.1150
86. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (CDC). Health, United States, 2020–2021. Available from: https://www.cdc.gov/nchs/hus/topics/health-care-expenditures.htm. Accessed October 15, 2022.
87. Jeffcoat MK, Jeffcoat RL, Gladowski PA, Bramson JB, Blum JJ. Impact of periodontal therapy on general health: evidence from insurance data for five systemic conditions. *Am J Prev Med*. 2014;47:166–174. doi:10.1016/j.amepre.2014.04.001
88. Nasseh K, Vujicic M, Glick M. The relationship between periodontal interventions and healthcare costs and utilization. evidence from an integrated dental, medical, and pharmacy commercial claims database. *Health Econ*. 2017;26(4):519–527. doi:10.1002/hec.3316
89. Lamster IB, Malloy KP, DiMura PM, et al. Dental services and health outcomes in the New York State Medicaid program. *J Dent Res*. 2021;100(9):928–934. doi:10.1177/00220345211007448
90. Lamster IB, Malloy KP, MiMura PM, et al. Preventive dental care is associated with improved health care outcomes and reduced costs for Medicaid members with diabetes. *Front Dent Med*. 2022. doi:10.3389/fdmed.2022.952182
91. Vujicic M. The booming Medicaid market. *J Am Dent Assoc*. 2015;146(2):136–138. doi:10.1016/j.adaj.2014.12.009
92. Center for Health Care Strategies, Inc. Medicaid adult dental benefits: an overview; 2019. Available from: https://www.chcs.org/resource/medicaid-adult-dental-benefits-overview/. Accessed February 26, 2022.
93. Families USA. Community statement on medicare coverage for medically necessary oral and dental health therapies; 2002. Available from: https://familiesusa.org/resources/community-statement-on-medicare-coverage-for-medically-necessary-oral-and-dental-health-therapies/. Accessed September 24, 2022.
94. Institute of Medicine. Committee on quality of health care in America. In: *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press; 2001.
95. Berwick DM, Nolan TW, Whittington J. The triple AIM: care, health, and cost. *Health Aff*. 2008;27(3):759–769. doi:10.1377/hlthaff.27.3.759
96. Nundy S, Cooper LA, Mate KS. The quintuple AIM for health care improvement: a new imperative to advance health equity. *JAMA*. 2022;327(6):521–522. doi:10.1001/jama.2021.25181

97. Epperly T, Bechtel C, Sweeney R, et al. The shared principles of primary care: a multistakeholder initiative to find a common voice. *Fam Med*. 2019;51(2):179–184. doi:10.22454/FamMed.2019.925587
98. Monaghesh E, Hajizadeh A. The role of telehealth during COVID-19 outbreak: a systematic review based on current evidence. *BMC Public Health*. 2020;20(1):1193. doi:10.1186/s12889-020-09301-4
99. Ghai S. Teledentistry during COVID-19 pandemic. *Diabetes Metab Syndr*. 2020;14(5):933–935. doi:10.1016/j.dsx.2020.06.029
100. Panch T, Mattie H, Atun R. Artificial intelligence and algorithmic bias: implications for health systems. *J Glob Health*. 2019;9(2):010318. doi:10.7189/jogh.09.020318
101. Abbate J, Guynap S. Oral health goes modern. Scientific American; 2016. Available from: https://www.scientificamerican.com/custom-media/the-future-of-oral-health/oral-health-goes-modern/. Accessed October 15, 2022.
102. Tanner ACR, Paster BJ, Lu SC, Kanasi E, Kent R, Van Dyke ST. Subgingival and tongue microbiota during early periodontitis. *J Dent Res*. 2006;85(4):318–323. doi:10.1177/154405910608500407
103. Tanner ACR, Kent R Jr, Kanasi E, et al. Clinical characteristics and microbiota of progressing slight chronic periodontitis in adults. *J Clin Periodontol*. 2007;34(11):917–930. doi:10.1111/j.1600-051X.2007.01126.x
104. Colombo APV, Tanner ACR. The role of bacterial biofilms in dental caries and periodontal and peri-implant diseases: a historical perspective. *J Dent Res*. 2019;98(4):373–385. doi:10.1177/0022034519830686
105. Garaicoa-Pazmino C, Decker AM, Polverini PJ. Personalized medicine approaches to the prevention, diagnosis, and treatment of chronic periodontitis. In: Polverini PJ, editor. *Personalized Oral Health Care: From Concept Design to Clinical Practice*. Switzerland: Springer International Publishing; 2015:99–112.
106. University of the Pacific. First dugoni school dental students give COVID-19 vaccines as part of expanded scope of practice; 2021. Available from: https://www.pacific.edu/pacific-newsroom/first-dugoni-school-dental-students-give-covid-19-vaccines-part-expanded-scope. Accessed October 15, 2022.
107. Stratton-Childers L. A shot worth taking: dentists in several states join the fight against COVID-19 by giving vaccinations. American Dental Education Association. Available from: https://www.adea.org/Articles/Jan2021-A-Shot-Worth-Taking/. Accessed October 15, 2022.
108. Foden-Vencil K. Oregon becomes 1st state to allow dentists to offer any vaccine. OPB Newsletter. Available from: https://www.opb.org/news/article/oregon-vaccines-dentists-health/. Accessed October 15, 2022.
109. Manski R, Rohde F, Ricks T. *Trends in the Number and Percentage of the Population with Any Dental or Medical Visits, 2003–2018*. Rockville, MD: Agency for Healthcare Research and Quality; 2021. Statistical Brief #537. Available from: https://www.meps.ahrq.gov/data_files/publications/st537/stat537.shtml. Accessed September 24, 2022.
110. Centers for Medicare and Medicaid Services (CMS), Office of the Actuary. CMS office of the actuary releases 2017–2026 projections of national health expenditures; 2018. Available from: https://www.cms.gov/newsroom/press-releases/cms-office-actuary-releases-2017-2026-projections-national-health-expenditures. Accessed July 12, 2022.
111. Glickman A, DiMagno SSP, Emanuel EJ. Next phase in effective cost control in health care. *JAMA*. 2019;321(12):1151–1152. doi:10.1001/jama.2019.1608
112. Basu S, Berkowitz SA, Phillips RL, Bitton A, Landon BE, Phillips RS. Association of primary care physician supply with population mortality in the United States, 2005–2015. *JAMA Intern Med*. 2019;179(4):506–514. doi:10.1001/jamainternmed.2018.7624
113. Levine DM, Landon BE, Linder JA. Quality and experience of outpatient care in the United States for adults with or without primary care. *JAMA Intern Med*. 2019;179(3):363–372. doi:10.1001/jamainternmed.2018.6716
114. Slavkin HC. The impact of research on the future of dental education: how research and innovation shape dental education and the dental profession. *J Dent Educ*. 2017;81(9):eS108–eS127. doi:10.21815/JDE.017.041
115. DePaola D, Slavkin HC. Reforming dental health professions education: a white paper. *J Dent Educ*. 2004;48(11):1139–1150. doi:10.1002/j.0022-0337.2004.68.11.tb03859.x
116. Hendrickson WD, Cohen PA. Oral health care in the 21st century: implications for dental and medical education. *Acad Med*. 2001;76(12):1181–1206. doi:10.1097/00001888-200112000-00009
117. Polverini PJ. *Personalized Oral Health Care: From Concept Design to Clinical Practice*. Switzerland: Springer International Publishing; 2015.
118. Wright JT. Genomics of dental caries and caries risk assessment. In: Polverini PJ, editor. *Personalized Oral Health Care: From Concept Design to Clinical Practice*. Switzerland: Springer International Publishing; 2015:87–98.
119. Slavkin HC. Personalized oral medicine and the contemporary health care environment. In: Polverini PJ, editor. *Personalized Oral Health Care: From Concept Design to Clinical Practice*. Switzerland: Springer International Publishing; 2015:1–18.
120. Slavkin HC. From high definition precision healthcare to precision public oral health: opportunities and challenges. *J Public Health Dent*. 2020;80(Suppl 1):S23–S30. doi:10.1111/jphd.12296
121. Divaris K. The era of the genome and dental medicine. *J Dent Res*. 2019;98(9):949–955. doi:10.1177/0022034519845674
122. Garcia I, Kuska R, Somerman MJ. Expanding the foundation for personalized medicine: implications and challenges for dentistry. *J Dent Res*. 2013;92(7Suppl):3S–10S. doi:10.1177/0022034513487209
123. Collins FS, Varmus H. A new initiative on precision medicine. *N Engl J Med*. 2015;372(9):793–795. doi:10.1056/NEJMp1500523
124. Department of Health and Human Services, Healthy People 2030. Oral conditions. Available from: https://health.gov/healthypeople/objectives-and-data/browse-objectives/oral-conditions. Accessed September 26, 2022.
125. Centers for Medicare and Medicaid Services. Fact sheet NHE. Available from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet. Accessed August, 2022.
126. Mather M, Jacobsen LA, Pollard KM. *Aging in the United States*. *Popul Bull*. 2015;70(2):2–21.
127. Ticku S, Barrow J, Fuccillo R, McDonough JE. Oral health stakeholders: a time for alignment and action. *Milbank Q*. 2021;99(4):882–903. doi:10.1111/1468-0009.12525
128. Mouradian W, Slayton, RL, Maas, WR et al. Progress in children‘s oral health since the Surgeon General‘s report on oral health. *Acad Pediatr*. 2009;9(6):374–379 doi:10.1016/j.acap.2009.09.023.