Oral Health in America

Advances and **Challenges**

Executive Summary

NIH

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Introductory Message

Two decades ago, Surgeon General David Satcher released a major report examining the nation's oral health. This first-time report was considered a public health milestone, emphatic in its assertion that oral health was inextricably linked to overall health and well-being. It also took great care to illuminate the stark disparities and inequities that exist with regard to disease burden and accessing and affording oral health care in this country.

Seventeen years after its publication, Dr. Satcher, along with Dr. Joyce H. Nottingham, partially assessed the progress made since the 2000 report, publishing a paper in the American Journal of Public Health. Based on emerging data, they offered the American people some early perspective in the form of good and bad news. The good, they proffered, was that "our understanding of oral diseases continues to grow." And the bad? Too many Americans still suffered from diseases of the mouth, the majority of which were related to oral health disparities.

That piece, it turns out, was a fitting, if unintended, prologue to this report, which is a sweeping, comprehensive effort to tell the whole story of the state of oral health in America. And, as the title suggests, in the last 20 years, there has been progress in some areas, and in others, a collective realization that far more work needs to be done.

It is our hope and intent that this report will serve as the foundation for that work. Work that—in light of a global pandemic that so plainly shows that the mouth is the gateway to the rest of the body and that those individuals and communities most affected in the pandemic are the same as those who so badly need oral health care—is perhaps more important than it has ever been. As this report describes, there is already promising research completed and underway to better understand the role the oral cavity plays with regard to SARS-CoV-2 transmission and infection. Research, innovation, and new technologies must continue to shine light into the dark corners of this global public health crisis.

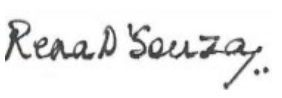
This report also sheds new light on how people in the United States experience oral health differently, based on their age, economic status, and a number of other social and commercial determinants. And, while good oral health is vitally important to the health and well-being of everyone, the report shows that oral health care has not been, and is not, equitably available across America.

Undoubtedly, you will see parallels to the 2000 report. As that document did, NIH, with the support of the Surgeon General, is also putting forth "calls to action" and specific recommendations on how to improve the oral health of our nation. In the following pages, we at the National Institute of Dental and Craniofacial Research, in concert with a vast array of editors and contributors, have painstakingly connected the dots that make up the constellation of amazing oral health research that has occurred since release of the first report at the turn of the century. With the utmost humility, the research team asked: "What have we learned?"

This report is their answer.

Vice Admiral Vivek H. Murthy, MD, MBA
U.S. Surgeon General

Francis S. Collins, MD, PhD
Director, National Institutes of Health



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Overview and Background

Oral health is essential to overall health and well-being. That relationship was a major conclusion of a Surgeon General's report on oral health some 20 years ago, yet the many ways in which oral health is related to general health remain obscure for most of us. And although we are aware that some individuals enjoy better oral health than others, we are less likely to understand why clear and strong differences in oral health—even inequities—are found for various groups of people within our society. Finally, we rarely acknowledge the ways in which oral health and disease are inextricably involved in major social and health challenges—including the ongoing crises of opioid misuse and the coronavirus (COVID-19) pandemic. Each of these observations, moreover, begs consideration of how best to address oral health challenges in ways that ultimately will improve the health and well-being of all.

Originally envisioned as an update to the 2000 publication of *Oral Health in America: A Report of the Surgeon General* (U.S. Department of Health and Human Services 2000), the current work, titled *Oral Health in America: Advances and Challenges*, has developed as a more far-reaching examination of the nation's oral health. It underscores the ways in which a broad array of health and human concerns are related, emphasizing especially the intersectionality of social and systemic determinants that can create both advantages and disadvantages with respect to oral health, and to health more generally. The report provided here is the result of exhaustive review of scientific knowledge accumulated during the last 20 years. It also is informed by systematic observations of recent influences on our society, especially those resulting from or illuminated by the ongoing COVID-19 pandemic. The unanticipated lessons still emerging from this unprecedented health event are demonstrating that considerable work lies ahead for all of us concerned with the nation's health.

Extraordinary achievements in science are creating health solutions that could not have been imagined just a few decades ago, and yet we remain challenged in our attempts to make these solutions available to all. In oral health—as in any area of health—realizing the full potential of scientific and technological innovation requires addressing inequities in the experience of health and disease, and pursuing the means to prevent, as well as to treat, illness. To do so necessitates understanding not only biological catalysts of disease but also many other factors operating at individual, family, and societal levels to mediate our experiences and our responses to oral disease. Demographic and socioeconomic factors serve to shape health experiences. Individual attributes and the cultural, environmental, and commercial aspects of communities—as well as the characteristics of health providers and the care delivery systems within which they work—all play critical roles in determining health experiences. If we are to improve the oral health of the population, these experiences and perspectives must be understood, along with the biological determinants of health and disease.

Several specific conclusions of the 2000 Surgeon General's report remain valid critiques or recommendations today. First, although microbial infections continue to be the primary cause of the most prevalent oral diseases, profound disparities in the experience of these diseases persist and can be explained only in terms of a complex interplay among risk factors and social determinants. Second, many systemic diseases and conditions, as well as

treatments for such conditions, have important oral manifestations; conversely, oral infections may place many individuals at greater risk for morbidity from a variety of causes. Third, effective approaches to disease prevention and oral health promotion are available, and these may require community action, as well as individual self-care behaviors and professional care. Fourth, our system for educating providers and delivering appropriate care to the population remains an important determinant of oral health. And fifth, the limited availability of dental insurance continues to be a major barrier to oral health for many Americans.

Since the 2000 report, our knowledge of the impact of poor oral health from a global perspective has expanded substantially. The 2016 Global Burden of Disease Study reported that among the 328 health-related conditions assessed, 4 among the 30 most prevalent diseases are related to oral health: untreated dental caries in adult teeth (#1), severe periodontitis (#11), untreated dental caries in baby teeth (#17), and severe or complete tooth loss (#29) (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators 2017). These oral diseases and conditions affect about 3.5 billion people worldwide. Additionally, craniofacial birth defects, and in particular, cleft lip and/or palate, occur as often as 1 in 700 live births (Cleft Lip and Palate Association 2021) and represent the most common congenital disorder after Down syndrome.

From a global perspective, oral health was described in a *Lancet* editorial as being at a "tipping point," where technological changes and consumer demands for esthetic dentistry are changing the perception of dental care and accelerating oral health disparities as more people face increasing barriers to receiving essential care for oral health (The Lancet 2019). If our idea of what oral health should be continues to move toward these newer expectations and trends, many are likely to remain disenfranchised from the benefits of good oral health as care becomes more unaffordable. The result will be more untreated disease, less access to prevention and care, and a lower quality of life for many groups of people.

Change Brings Advances and Challenges

The population of the United States has changed substantially during the last 20 years. We are a more diverse nation than ever in terms of racial, ethnic, religious, and other differences that describe us socially and culturally. Moreover, the United States is an aging nation. By 2035, there will be more adults over age 65 than there will be youth in our country (U.S. Census Bureau 2018), and the health care needs of older adults are quite different from those of younger people.

The exponential digitization affecting our communications and information management has transformed our daily lives. Technological changes have substantially altered the way we receive health care, and technology now has become the single most important driver for health care spending in the United States (National Research Council 2002). Contemporary dentistry is increasingly reliant on digital technologies for imaging, treatment planning, manufacturing, and recordkeeping. For a nation with oral health inequities, a greater dependence on higher-cost technology to deliver care has the potential to exacerbate disparities as more people defer dental care because of costs. Dental expenses constitute more than a quarter of overall health care out-of-pocket expenditures and are reported to present higher financial barriers than medical, prescription pharmaceutical, and mental health care. This especially affects working-age adults, followed by older adults, and then by those age 18 and younger (Vujicic et al. 2016).

Although an individual's oral health habits—diet, toothbrushing, use of fluoride toothpaste, flossing, and visiting the dentist—play a role in ensuring good oral health, there are other circumstances that can be even more important. These are the broad, systemic factors called social determinants of health (SDoH) (see Figure 3, Section 1 of the report). Individual health is determined in varying degrees by access to social and economic opportunities; access to quality education; the resources and support available in our homes, neighborhoods, and communities; the safety of our workplaces; the cleanliness of our water, food, and air; and the nature of our social interactions and relationships. During the past 20 years, we have begun to develop greater knowledge about how oral health is affected by these determinants and why they differentially affect various groups of people.

These differences in health among population groups usually are labeled health disparities, and when viewed as unfair, are described as health inequities. Although the

challenge of health inequities is formidable, it is inseparable from the goal of achieving oral health for all. Meaningful improvements in population oral health will occur only if our efforts are tailored to address underlying structural, cultural, and interpersonal biases that lead to persisting disparities.

During the last 2 decades, numerous initiatives have been aimed at improving the oral health of young children in the United States. Inspired by the 2000 Surgeon General's report, dental providers, researchers, policymakers, advocates, and many others launched programs to address early childhood caries (ECC) in preschool children. These efforts have led to important changes that influence the way we now prevent and control dental caries in young children—from promoting first dental visits at age 1, to risk assessment and delivery of care using newer techniques and products, such as fluoride varnish. Moreover, several initiatives promoted the integration of oral health services into medical (primary) care. For example, pediatric oral health professionals have worked with physicians to develop procedures to serve infants and toddlers during well-child visits, which routinely occur several times before a child is 3 years old. Finally, improvements to Medicaid and the Children's Health Insurance Program (CHIP) have substantially expanded dental insurance coverage for many children, thereby improving access to dental care for those from lower-income families. Taken together, such efforts have resulted in the reduction of untreated tooth decay by nearly 50% in preschool children (see Figure 13, Section 2A of the report), a historically low prevalence of ECC.

There have been other notable advances affecting oral health in America since 2000. The expanded use of dental sealants, an important caries prevention service, has led to meaningful reductions of some oral health disparities by race/ethnicity and income for many children. Tooth loss continues to decline across all subgroups of adults. Among adults aged 65–74 years, only 13% are edentulous today, compared with 50% in the 1960s. Impressive progress has been made in how dental care is provided—from the use of advanced dental materials to restore form and function of the dentition when filling a cavity, making crowns, and replacing missing teeth—to diagnosing, treatment planning, and managing oral pain. There has been a fourfold increase in the percentage of older adults receiving dental implants during the last 20 years. Major advances in implant technology and practice have made the placing of implants faster and more successful than ever before, improving quality of life for many. Unfortunately, implant procedures remain costly and, therefore, out of reach for most adults.

Another significant advance during the past 20 years has been our new understanding of the microbiome, the community of microbes—both beneficial and harmful—that inhabit our bodies. The oral microbiome is made up of the bacteria, fungi, and viruses that live in our mouths; we have more of these microbes in our mouths than in any other part of the body except the gut (Deo and Deshmukh 2019). Most microbes in the mouth live within organized structures called biofilms (also known as dental plaque), which stick to most surfaces in the mouth, including the teeth, tongue, oral mucosa, dental restorations, dental implants, and dentures. In-depth knowledge of the oral microbiome is moving us closer to the promise of personalized oral health care, in which specific microbial therapies can be individually developed to prevent, manage, and treat oral diseases.

Our understanding of the importance of pathogenic microbes to oral health also has improved significantly during the last 2 decades. This is important because the three main oral diseases—dental caries, periodontitis, and oropharyngeal cancer—begin with an underlying microbial dependence. The dental caries process starts with demineralization, followed by bacterial penetration and the establishment of an irreversible carious lesion. With regard to periodontal disease, we now know that only a very small number of bacterial species are implicated in the pathogenesis of periodontal disease. During the last 2 decades, the effects of periodontal disease have been studied in relation to nearly 60 other adverse health conditions (see Figure 26, Section 3A of the report), most of which have underlying microbial components as well. Finally, the significant increase in oropharyngeal cancer observed since the 2000 report on oral health has been clearly linked to infection by the human papillomavirus (HPV).

Although progress made in advancing oral health in America during the past 20 years has been significant, several challenges persist, and new threats have emerged. We have long known that tobacco affects oral tissues and is directly implicated in oral cancer as well as in

periodontal disease. Fortunately, the prevalence of cigarette smoking continues to decline, but the upward trend in the use of e-cigarettes, or vaping products for tobacco or marijuana, has become more common in recent years, especially among youth and young adults, representing a new threat to oral health that requires more work for full understanding.

The causal role of HPV infection in several cancers has been substantially elucidated in recent years. Oropharyngeal cancer is now the most common HPV-associated cancer, more common than cervical cancer, and men are 3.5 times more likely to have oropharyngeal cancer than women. The good news is that we now have vaccines that are approximately 90% effective in preventing HPV infection. The oral health profession needs to become more actively involved in promoting health, encouraging appropriate behavioral changes, and supporting the vaccination of adolescents.

There are other health threats that are inextricably related to oral health. More Americans than ever before are reporting mental illness. Both acute and chronic versions of these conditions may cause neglect of oral health, and medications used to treat mental illnesses frequently have deleterious effects on oral tissues.

Millions of Americans suffer from, or are at risk of developing, substance use disorders (see Figure 4, Section 5 of the report). These experiences can affect oral health directly, in terms of impact on oral tissues, and behaviorally, when oral health is neglected or there is difficulty in accessing professional care. Moreover, dentistry has been implicated in the epidemic of opioid misuse because, for many years, these medications were commonly prescribed for the alleviation of dental pain. Recognizing the resulting problems, the dental profession has developed guidelines for safer approaches to treating pain, and efforts are being made to ensure education about the implications of substance use.

Providing compassionate, high-quality care and treating pain require accurate and timely access to patients' health histories. Dental professionals sometimes struggle to fully understand patients' underlying medical conditions because medical and dental records remain largely separate. Integrated medical and dental records build on our knowledge of the connection between oral and overall health (see Figure 5, Section 6 of the report). They also make it easier for health care providers to understand a patient's health and history at the point of care, which can lead to fewer errors and more individualized treatment. For the past 20 years, the integrated electronic health record (EHR) has been only a rarely achieved aspiration, but with today's remarkable advances in technology, universal adoption of the EHR seems more possible than ever before. There will be obstacles to overcome, but the advantages will be well worth the struggle.

One overarching challenge to oral health that has persisted during the last 20 years is the inadequate access to dental care that adversely affects millions of individuals and their families. This particularly affects older adults who do not have dental insurance coverage, and unlike for children and adolescents, there are few programs to address this issue. This chronic lack of access to oral health care leads inevitably to untreated disease and, frequently, to pain. One reason for inadequate access to care is that the United States continues to experience dental health professional shortage areas affecting millions of Americans (see Figure 5, Section 4 of the report). Some estimate that at least 10,000 additional dental health practitioners are needed to help fill these gaps, and this doesn't take into account demographic factors affecting the composition of a growing U.S. population.

The shortage of dental professionals has led to the development of a variety of new service delivery models and to new settings for service delivery. The practice of dental therapy, for example, was begun in 2000 to provide dental services in Alaska Native rural villages, thereby addressing acute dental care shortages in the most rural parts of Alaska. Other states now are developing or exploring their own approaches to that model. The Surgeon General's 2003 *National Call to Action to Promote Oral Health* (U.S. Department of Health and Human Services 2003) emphasized the need for public-private partnerships to improve the oral health of all Americans and called for collaborative efforts to integrate general medical care and oral health care. During the past 2 decades, interprofessional initiatives have expanded access to oral health services, in part by integrating dental and medical education and practice. Since then, models have emerged for multidisciplinary teams of health professionals to deliver oral health care in a variety of settings outside the dental office (Harnagea et al. 2018).

These models usually seek to (1) expand the number and type of patients who can obtain care, (2) improve patient outcomes, and (3) reduce the cost of care.

The annual cost of dental care in the United States was nearly $136 billion in 2018, representing 3.7% of the total health care spending in the nation. Of this amount, $55 billion was paid personally by patients (see Figure 3, Section 4 of the report), and these dental expenses make up more than a quarter of all health care out-of-pocket spending (Vujicic et al. 2016). Although increased dental insurance and interprofessional care have helped children gain access to oral health care, adults still face many barriers to obtaining care. A chief obstacle—especially for older adults—has been the difficulty of obtaining and using dental insurance. Even when policies are affordable, they generally limit dental benefits and require large out-of-pocket payments. Dental coverage is not as widespread as medical insurance because it is treated as an add-on to health insurance, rather than an essential part of it. With or without insurance, some people simply cannot afford dental care (Vujicic et al. 2016). The resulting deferral of care results in expensive consequences that could have been avoided if oral health services for all individuals were considered an essential health benefit.

Several of the advances and challenges that have affected oral health in America during the last 2 decades also have shaped the global oral health landscape. The prevalence of untreated oral diseases has grown, with an estimated 3.5 billion people affected worldwide. And the same social and commercial determinants of health that have strongly influenced oral health in America also critically impact global oral health (Peres et al. 2019). To address this important issue, in 2021, the World Health Organization (WHO) adopted a resolution calling for the creation of a global oral health strategy, including a recommendation that dental care be mandated within a universal health coverage agenda (Benzian et al. 2021).

Oral health may be at a tipping point in America. During the last 20 years, evidence has been mounting for the essential role of oral health within a long and healthy life. We know that good oral health represents not only the ability to freely eat, smile, speak, and interact with others, but also to have freedom from stigma related to dysfunctional conditions or pain that can interfere with normal functioning. Oral health problems can occur at any point in our lives, but more often than not, they are preventable through individual, family, and community efforts. Reflecting on both the achievements in oral health during the last 2 decades and the ongoing challenges, it is clear that there have been valuable lessons to demonstrate important and viable paths forward. The future direction of oral health in America now rests on the actions we will take to ensure that everyone has the opportunity to enjoy the benefits of good oral health tomorrow.

Organization and Preparation of the Report

This report of the National Institute of Dental and Craniofacial Research (NIDCR), *Oral Health in America: Advances and Challenges*, is only the second comprehensive document on this topic and the first in more than 20 years. In 2018, NIDCR was asked by then–Surgeon General Jerome Adams to lead the development of a new report on oral health (U.S. Department of Health and Human Services 2018). The goal was to update the status of oral health and its relationship to overall health as reported in 2000, with attention to disparities and addressing inequities. The decision was made to consider these differences in oral health across the lifespan, along with the largely unaddressed health challenges of mental health and substance use. The report was intended to take into consideration new scientific and technological knowledge, as well as innovations in health care delivery that indicate promising new directions for improving oral health care and creating greater equity in oral health across communities. As the report was being developed, however, the emergence of the COVID-19 pandemic imposed a compelling need to address oral health in the context of this new health crisis. Recognizing the long-term implications of COVID-19 and the potential for similar events in the future, the process of developing the report was adjusted to identify and add as much relevant content as possible.

This complex framework within which oral health needs to be studied and understood is now reflected in the structure of the report, which chronicles key areas of progress and promising practices, as well as persistent challenges and emerging threats affecting oral health during the last 20 years. The titles of the six major sections of the report provide a guide for exploring major content

areas from these perspectives: (1) Effects of Oral Health on the Overall Well-Being of Individuals, Communities, and the Economy; (2) Oral Health Across the Lifespan: (a) Children and b) Adolescents; (3) Oral Health Across the Lifespan: a) Working-Age Adults and b) Older Adults; (4) Oral Health Integration, Workforce, and Practice; (5) Pain, Mental Health, Substance Use, and Oral Health; and (6) Emerging Science and Promising Technologies to Transform Oral Health.

The compilation of this work draws primarily on information from scientific investigation and evidence-based practices, supplemented by descriptions of programs that reflect important new directions. A large and diverse team of experts was sought for the task, with the result that several hundred individuals directly engaged in the preparation of the report. This group included more than 350 contributors who addressed specific topics for inclusion in the report: 26 section and section associate editors, 2 lead editors, nearly 70 scientific reviewers, and 9 senior reviewers. In addition, an estimated 200 professionals contributed descriptions of innovative programs and approaches for addressing oral health challenges during the early development of the report.

Including the initial draft of the six major report sections using contributed material, the report underwent 10 major revisions. In addition to multiple internal reviews, the report was subjected to two major peer review cycles that further shaped the topics included and added new perspectives. During the first review, subject matter experts reviewed assigned sections and evaluated content for scientific integrity and accuracy. The second review involved comprehensive critiques of the full report, with senior reviewers evaluating content from a broader perspective, focusing on relevancy and integrity. An extensive federal clearance process was undertaken, which served as a third and final review of the report. Throughout these review processes, content was updated and revised to include information not available when the original draft was created; coverage was coordinated across sections; and major findings and developing themes were clarified.

Within each of the six sections of the report, content is further organized into four chapters. Chapter 1 reviews current knowledge, status, and perspectives for the key themes discussed within each section. Chapter 2 highlights important advances and challenges of the last 20 years as they relate to the section topics. Chapter 3 presents activities and initiatives that show promise for improving oral health, including showcasing some novel partnerships suggested by the public. The section then concludes with a summary (Chapter 4) and presentation of the key messages and a call to action. Summary information, including these messages, from each of the six sections of the report are also presented later in this Executive Summary.

The Impact of COVID-19 on the Report

The report team was well immersed in the content of this monograph in early 2020 when our nation and the entire world were stunned by the emergence of the most devastating and far-reaching public health crisis since the Influenza Pandemic of 1918. The team was faced with a variety of challenges to completion of the report and, most critically, with the problem of how to incorporate emerging, and sometimes shifting, information into the report. It was immediately apparent that COVID-19 was seriously affecting access to oral health care, and it quickly became clear that it would unalterably affect the ways in which that care is delivered. Dental offices were closed and, as they began to reopen, new questions emerged about how to ensure the safety of both patients and providers in the process of receiving and providing oral health care. A particularly painful observation at this point in the work was that those with the greatest need for oral health care—those living in poverty or with special health care needs, the elderly, and members of racial minority groups—were the groups most impacted by the virus. The longer we lived with the pandemic, the more obvious it was that its influence would need to become an ongoing aspect of the way we think about oral health, as well as health more generally.

Scientific information about the ways in which oral health is directly impacted by the virus in those who are infected still remains an active area of discovery. We are beginning to see research related to the mouth as a potential locus of SARS-CoV-2 infection, as well as a site where symptoms of the virus manifest. To the extent time has permitted, acknowledgment of the influence of COVID-19 on the

delivery of oral health care, workforce education, and oral health research can be found throughout several sections of this report.

Section Summaries and Key Messages

Section 1: Effects of Oral Health on the Overall Well-Being of Individuals, Communities, and the Economy

Good oral health supports the overall health and well-being of individuals, families, communities, and the nation. Oral health is determined by many personal, social, and environmental factors, including genetics, behavior, diet, socioeconomic status, geography, and living conditions, as well as broader cultural influences, and commercial motives and determinants. There are direct (treatment expenditures), indirect (productivity losses attributable to absence from school and work), and intangible costs (detrimental impacts on quality of life) related to orofacial diseases. The incidence of oral diseases, like many chronic disease conditions, is socially patterned, with the largest burden of disease occurring among marginalized groups, including those living in poverty, racial and ethnic minorities, frail elderly, immigrant populations, those with special health care needs, and others. All of these groups suffer higher burdens of oral disease and may face numerous barriers to accessing routine preventive and other dental services.

Disparities in the experience of oral disease may result from systemic differences in the availability of social and economic health-promoting resources, including access to affordable healthy foods, professional dental prevention and treatment services, and dental insurance. These disparities reflect structural biases, are unjust, and are more correctly described as inequities. In the United States, the largest of such disparities in access to dental care are related to income and race/ethnicity. A new understanding has emerged that the causes of poor oral health are the result of complex interactions of determinants. These include a subset of social determinants, usually referred to as commercial determinants. Commercial entities often provide excellent products that support oral health, and some also market products such as tobacco, alcohol, and sugar-sweetened foods and beverages that are detrimental to oral and overall health. The marketing, pricing, and subsidization of these commodities can influence and drive consumption patterns of unhealthy products. By shaping consumer preferences, affecting physical and social environments, and influencing public policy development, commercial determinants influence the health of individuals and populations and can drive associated disparities.

Health and the economy are inextricably linked, meaning we cannot have healthy communities without a prosperous economy, and we cannot have a prosperous economy without healthy communities. Productivity losses in the United States associated with untreated oral disease were estimated to be $45.9 billion in 2015. The disproportionate burden of untreated oral disease that is carried by marginalized groups underscores the role of social determinants in our economy, as well as in the health of individuals. A Surgeon General's Report on Community Health and Economic Prosperity acknowledged the influence "of structural, cultural, and interpersonal racism and bias on health, wealth, and well-being" (U.S. Department of Health and Human Services 2021). Clearly, strengthening the health of communities requires eliminating the causes of gaps in health status and gaps in access to care within and across our communities.

Lack of access to regular dental care can result in ineffective and expensive overuse of hospital emergency departments (EDs)—another negative impact on our economy. In 2014, there were 2.4 million ED visits for nontraumatic dental conditions, representing more than $1.6 billion in charges. Medicaid was reportedly the primary payer for these visits. Dental care provided in EDs is most often palliative, with an estimated 90% of patients receiving only pain medication or antibiotics and a referral to dental providers for treatment.

During the past 20 years, dental care costs per person in the United States have increased 30%, placing access to dental care out of reach for many. But the consequence of having large segments of society experiencing chronic and often painful, untreated, oral conditions also carries a cost. Our current patchwork of dental care financing continues to create major gaps in access to affordable dental care for many vulnerable groups. These same

groups tend to suffer disproportionate levels of dental disease, with little hope of obtaining needed care. Having large segments of society suffer from persistent untreated oral disease creates economic and societal costs that harm individuals, families, and communities. Key messages are in Box 4, Section 1.

Section 2A: Oral Health Across the Lifespan: Children (ages 11 years and younger)

Experiences during childhood lay the foundation for oral health in later years, and there are many influences on oral health during these early stages of life. For these reasons, children have been the first focus of those involved in promoting oral health and in preventing oral disease. Ultimately, children's behaviors are shaped by the beliefs and behaviors of parents and other caregivers, as well as by SDoH and societal, cultural, and commercial factors that influence health outcomes.

Dental caries, the disease process that causes tooth decay, is one of the most common chronic diseases affecting children in the United States as well as globally. More than 530 million children worldwide have untreated caries in primary (baby) teeth, with the prevalence of disease increasing with age. Health care agencies, such as WHO, have identified dental caries in children worldwide as a major public health problem and have issued reports characterizing the condition and strategies for prevention.

Since the publication of Oral Health in America in 2000, advances in prevention and expanded access to treatment have improved oral health for children in the United States. Untreated tooth decay in primary teeth has significantly decreased in children younger than 12 (23% to 15%), and this change has been greatest for children aged 2–5 years, with caries experience decreasing from at least 19% to 10%. These improvements affect preschool children across all racial and ethnic groups and family income levels, with larger declines in untreated caries benefiting minority and low-income children the most by reducing long-established health disparities for this important oral health metric.

For children aged 6–11 years, the prevalence of dental cavities in permanent teeth also has declined significantly during the past 20 years, from 25% to 18%. However, children in this age group who live in lower-income households have seen less improvement in caries experience than those living in higher-income households (28% to 24% vs. 22% to 13%). This reflects a health disparity that seems to have persisted during the past 20 years, in spite of efforts to address the needs of these children.

Although caries is largely preventable, if untreated it can lead to pain, inflammation, and the spread of infection to bone and soft tissue. Children may suffer from difficulty eating, poor nutrition, delayed physical development, and poor self-image and socialization. Even academic performance can be affected. Fluoridated water, toothpastes, and varnish—as well as dental sealants—can work together to dramatically reduce the incidence of caries. Sealants typically protect against 80% of cavities for 2 years and continue to protect against 50% of cavities for up to 4 years. Substantial progress has been made in the past 20 years providing sealants to school-age children in the United States. The prevalence of at least one sealed permanent molar in children 6 to 8 years has more than doubled, from 14% to 31%. The largest gains, among Mexican American children and children living in poverty (an estimated fivefold increase), have nearly eliminated this health disparity in prevention for these groups. Similar gains in the prevalence of dental sealants among children aged 9–11 years have been observed as well (29% to 53%).

Orofacial birth defects, including cleft lip and/or cleft palate, represent the second most common birth defect and usually require lifelong, multidisciplinary care that places substantial burdens on affected children and their families. Fortunately, progress is being made in identifying the genes responsible for cleft lip and/or cleft palate. Ultrasound imaging can detect defects as early as 5 weeks in utero, and new approaches to surgical intervention can reduce disability and improve overall health through adulthood. In preschool-age children, dental trauma is one of the more common injuries, accounting for almost 20% of all physical injuries among young children. The highest incidence of oral trauma affects primary maxillary incisors in children aged 2–3 years, when motor skills are developing.

Almost 20% of children have special physical or health care needs that impact oral health. These special needs can stem from orofacial conditions, such as cleft lip

and/or cleft palate, or from more general physical or developmental disabilities that impede adherence to oral hygiene routines or require special accommodations during dental treatment. Oral health care is one of the most common unmet health care needs for these children. Providers must be trained in the active prevention and management of these children's oral health problems to support their overall health and quality of life.

During the past 20 years, several early childhood oral health promotion programs, focusing mostly on oral health education and preventive services, have shown promising results. The programs address family-level health behaviors to prevent the early development of caries. They target predominantly urban, low-income populations with approaches grounded in behavioral theory, caries risk assessment, and public health principles, and some have incorporated pharmacologic treatments such as fluoride varnish or silver diamine fluoride.

There have been several important initiatives during the last 20 years that have contributed to improvements in children's oral health. For example, many health and professional organizations now recommend the first dental visit by age 1 to help parents and caregivers expose their young children early to good oral health practices and monitor for early childhood dental caries. A doubling of the pediatric dental workforce has made services more widely available, enrollment of children into Medicaid and CHIP has increased, and states' performance in delivering care to their beneficiaries has improved. Collectively, these actions have helped to improve access to dental care for more low-income children. Today, 9 in 10 children have dental insurance in the United States. Integrating dental care within family and pediatric medical care settings has been another important advancement. The delivery of preventive oral health services, such as fluoride varnish, during well-child visits in medical offices is showing promise in reducing dental caries among preschool-age children. Well-child medical visits are providing more opportunities for families to access preventive oral health services in general and to receive referrals to dentists for their young children when needed.

Increasing the integration of oral health care with medical primary care has led to an initiative supported by the Health Resources and Services Administration's (HRSA) Integration of Oral Health and Primary Care Practice. The program provides a framework for the successful integration of oral health with primary care through five domains of clinical activities and competencies: risk assessment, oral health evaluation, prevention intervention, communication and education, and interprofessional collaborative practice. Challenges persist, however, including resistance by providers, lack of training, and the need for insurance reimbursement for services.

Childhood represents a pivotal time for the prevention of caries and other oral diseases and conditions, and the 2000 Surgeon General's report on oral health in America provided impetus for some major advances. The themes that have emerged from 20 years of focus on oral health in young children include the need to further develop our understanding of the biological basis of dental caries and to develop more effective strategies for prevention. A full exploration of social determinants is also critical for understanding the emergence of disease. Our challenge for the future is to advance and extend the promising new preventive and therapeutic approaches that have been developed and to ensure their availability to all children through systems of care that meet their diverse needs (Box 2, Section 2A).

Section 2B: Oral Health Across the Lifespan: Adolescents (ages 12–19 years)

Adolescence is a critical time for establishing independent and positive lifelong oral health habits. Unfortunately, many adolescents lose eligibility for dental coverage as they enter adulthood and are no longer covered by Medicaid, CHIP, or a family dental plan. Adolescents experience many biological, developmental, and social transitions, including puberty, increasing autonomy in behavior, and cognitive changes that advance abstract thinking and problem solving. Both positive and negative beliefs and habits related to health can emerge and carry into young adulthood and beyond. Yet adolescence often has been overlooked in programs to study, evaluate, and improve oral health; this group simply has been overshadowed by programs aimed at younger children or adults.

Although the oral health of young children generally has improved during the past 20 years, similar advances have not been seen for adolescents (aged 12–19 years). In particular, there has been no significant change in dental cavities, or caries. Nearly 3 in 5 adolescents (57%) have experienced dental cavities, with the highest rate among Mexican Americans (69%). Socioeconomic and racial/ethnic disparities in caries among adolescents have changed during the past 2 decades. The disparity between Mexican American and non-Hispanic White adolescents is increasing, although the disparity between non-Hispanic Black and non-Hispanic White adolescents has declined. Across these categories, however, the disparity between lower-income adolescents and more affluent adolescents is substantially increasing.

Although there has been little progress in preventing dental cavities in adolescents, there has been a small improvement in the prevalence of untreated tooth decay. About 1 in 6 adolescents has untreated tooth decay, a decline of about 3%. Caries remains most prevalent among adolescents living in poverty, affecting about 23% of that group. Prevalence is even higher for American Indian/Alaska Native (AI/AN) adolescents; at least 2 out of 5 AI/AN teenagers aged 13–15 years have untreated tooth decay. Although overall this problem is declining among lower-income adolescents, the prevalence of untreated tooth decay is higher than asthma or cigarette smoking, which garner much more public health attention. The fact that we are seeing fewer lower-income or minority children with untreated tooth decay today, compared to 20 years ago, suggests that more are receiving dental care. Preventing tooth decay in adolescents, however, remains an important and challenging goal.

As seen in younger children, the progress made in increasing sealant placements for adolescents since publication of the 2000 Surgeon General's report on oral health has helped to dramatically reduce the income and race-related disparities for this important preventive service. During the past 20 years, the prevalence of at least one sealed permanent molar in adolescents aged 12–19 has nearly tripled, increasing from 18% to 48%. Very large gains have occurred for non-Hispanic Black and Mexican American adolescents (8% to 37%, and 8% to 44%, respectively). For adolescents living in poverty, the proportion of those with at least one permanent tooth sealed has substantially increased, from 12% to 43%.

Although dental caries continues to be the major oral disease in adolescents, other conditions, such as traumatic injuries to the head and face and periodontal-related conditions, also can occur. The psychosocial aspects of oral health are especially significant in adolescence, including the capacity to speak, smile, and interact in social situations as youngsters are developing adult identities through interactions with their peers. Appearance becomes highly important just at the time when many in this age group are being treated for malocclusion with orthodontic appliances or braces. Unfortunately, there is little systematically collected contemporary information on other dental conditions affecting adolescents, such as periodontitis, dental fluorosis, dental erosion, and tooth wear.

Use of alcohol, illicit drugs, and tobacco remain important risk factors affecting oral health among adolescents, with consequences that can extend into adulthood. The use of e-cigarettes and vaping products containing nicotine and marijuana has risen dramatically among youth. The use of e-cigarettes in adolescence may increase the risk of combustible cigarette smoking in the future. In 2020, more than 1 in 8 (3.6 million) middle and high school students in the United States used e-cigarettes, which continues to be an urgent public health concern.

Major health promotion activities for adolescents tend to focus on healthy eating, including refraining from consuming beverages high in sugar and caffeine; the avoidance of substance use such as smoking, vaping, drinking, and the use of illicit drugs; vaccination against HPV to prevent oral cancer; the use of protective appliances during contact sports; orthodontia to promote self-esteem and long-term tooth wear and function; and regular dental care. Oral health professionals have key roles to play in interventions supporting these activities.

Adolescence is the best time for vaccination against HPV, the most common sexually transmitted infection in the United States, with 79 million Americans infected. Although most HPV infections remain asymptomatic and resolve spontaneously in a few months, persistent HPV infection has been associated with most oropharyngeal cancers (OPCs). Reports indicate that HPV vaccination is

more than 90% effective in preventing cancer-causing oral HPV infections, oral HPV 16 in particular. The Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices recommends HPV vaccination at 11 to 12 years for both males and females, and a catch-up HPV vaccine at 26 years. In 2018, half of U.S. adolescents aged 13–17 years were fully vaccinated, and 68% had received at least one dose of the HPV vaccine. Oregon recently became the first state to change its regulations to permit dentists to provide vaccines, including the HPV vaccine.

Adolescence is perhaps the least understood age group of the lifespan, but it offers great potential for improving oral health in adulthood. Since the publication of the 2000 Surgeon General's report on oral health, three main themes have emerged related to the oral health of adolescents in the United States (Box 2, Section 2B). Dental caries continues to be an important concern for adolescents, but periodontal disease, dental erosion, temporomandibular joint disorders, and sexually transmitted infections, particularly HPV, warrant attention. Social and commercial determinants affect health behaviors in adolescents and how they seek care. Finally, the adolescent transition is marked by new behaviors, including risk taking, emotional and psychological disorders, and the use of alcohol, tobacco products, and other drugs—all of which have oral health consequences.

Section 3A: Oral Health Across the Lifespan: Working-Age Adults (ages 20–64 years)

In adulthood, the relationship between oral health and overall health becomes much more apparent and manifests in a variety of ways. The effects of periodontal disease—a chronic disease affecting the gums, bone, and other supporting tissues around teeth—has been studied in relation to nearly 60 other adverse health conditions, including diabetes, heart disease, and Alzheimer's disease. Patients with head and neck cancer who undergo radiation therapy experience damage to the salivary glands, leading to lifelong battles with dry mouth, increased dental decay, mucosal tissue swelling, and periodontal infections. Infection from oral HPV increases the risk for some cancers, including OPC. Finally, risky behaviors such as smoking, drinking, and opioid use continue to have a negative impact on oral health.

Overall, U.S. adults' oral health has not improved—and in some respects has worsened—since publication of the 2000 Surgeon General's report on oral health. Inequities in oral health that have been well documented for children also characterize the health of working-age adults. Oral diseases are common and can have a significant impact on quality of life. Tooth loss affects the ability to eat a balanced diet, to speak, chew, swallow, and smile, and is associated with greater illness and earlier than average death. Tooth loss, untreated tooth decay, and moderate to severe periodontal disease occur throughout the adult population and often worsen as people age. These conditions contribute to impaired oral function, which also impacts social and emotional well-being.

The two most prevalent oral diseases affecting adults are dental caries and periodontal (gum) disease. Caries affects 9 of 10 working-age adults aged 20–64 years in the United States, with no substantive change in prevalence during the past 20 years. Periodontal disease also remains common in this age group, affecting at least 2 in 5 adults aged 45–64 years. Severe periodontitis affects 1 in 10 working-age adults aged 45–64 years.

Unlike the progress seen in younger children, there has been no change in untreated dental caries in working-age adults during the past 2 decades (28% vs. 29%), and the disparities for untreated caries continue to be substantial. More than half of working-age adults living in poverty have untreated caries (52%), whereas only 1 out of 5 nonpoor adults have untreated caries (20%). Twenty years ago, a typical working-age adult living in poverty had about four tooth surfaces affected by untreated caries, whereas a more affluent adult had only one tooth surface affected by untreated caries. Now, the mean number of surfaces affected by untreated caries has increased by 50% for working-age adults, regardless of poverty status.

During the past 20 years, approaches to prevent, diagnose, and manage dental caries have changed. An important aspect of this change has been a minimally invasive, nonsurgical approach to dental caries management that includes risk assessment and a treatment focus more on remineralization and caries arrestment when possible. The use of fluorides continues to have an important role in preventing and controlling dental caries, but new

information over the past decade is helping us to better understand how the targeted use of fluorides—in the form of rinses, gels, and varnishes—can be used effectively with working-age adults. Silver diamine fluoride also has reemerged in the last decade as an important noninvasive intervention to prevent and control dental caries in adults.

Tooth loss affects adults of all ages, but complete tooth loss (edentulism) continues to decline. Among older working-age adults aged 50–64, an estimated 6% are edentulous, with more than 17% of those living in poverty experiencing complete tooth loss. Three in four adults aged 50–64 have a functional dentition (sufficient number of natural teeth), but substantial oral health disparities exist in relation to socioeconomic indicators. Among those living in poverty, only about 47% have a functional dentition, whereas 83% of nonpoor adults aged 50–64 years have a functional dentition. During the past 20 years, significant advances in the restorative management of tooth loss have occurred. The development of improved technologies for dental implants to replace lost teeth has led to a reduction in complications and improved outcomes for these procedures.

OPCs associated with HPV have increased at a troubling rate for this age group. During the past 20 years, HPV-associated oral cancers have doubled, with men having 3.5 times more OPC than women. While tobacco-related OPC incidence (and cancer rates generally) have declined as a result of decreased tobacco use, the incidence of HPV-related OPCs has risen with changing sexual practices. Seven out of ten OPCs in the United States are caused by HPV, and the number of new cases is increasing each year—making OPCs the most common HPV-related cancer in the United States. Among those with OPC, about 2 in 3 survive 5 years or more after diagnosis. OPCs remain a public health concern because of their relatively high mortality rates and because they are among the most debilitating and disfiguring of all malignancies.

Nearly 1 in 5 adults may experience moderate to high dental fear or anxiety, preventing some from seeking needed oral health care; an estimated 7% experience high levels of fear and anxiety. Although onset during childhood is most frequent, dental fear/anxiety can develop at any age and typically remains stable across the lifespan. Dental fear and anxiety strongly impact utilization of dental care, even among those with access to care, and are associated with delayed appointment scheduling, canceled or missed appointments, and avoidance of necessary treatment.

Dental insurance has been shown to improve access to dental care, but many working-age adults—especially low-income and minority adults—don't have such coverage. Although dental coverage for children has improved, access to dental insurance for adults has generally remained unchanged since 2000. The Affordable Care Act included dental care as an essential health benefit for children, but not for adults (Vujicic 2014). In 2021, only 23 states offered comprehensive dental benefits to adults enrolled in Medicaid. Overall, more than 1 in 4 working-age adults have no dental insurance. About half of working-age adults with private dental insurance have had a dental visit in the past 12 months, whereas only 1 in 5 with public dental insurance and 1 in 6 with no insurance had a dental visit. Among working-age adults, 20% indicated they needed dental care but did not get it in the past 12 months, with financing concerns most often reported as the reason. Working-age adults are more likely to defer dental care because of costs rather than defer medical care, mental health care, eye care, and filling prescriptions. Key summary messages for this age group are shown in Box 2, Section 3A.

Section 3B: Oral Health Across the Lifespan: Older Adults

The segment of the U.S. population who are 65 years and older is growing rapidly, and this will significantly impact oral health and dental care over the next 2 decades. Since 2000, older adults have continued to have fewer teeth extracted, and the proportion with total tooth loss is at an all-time low. Although older adults generally are enjoying the benefits of improved oral health—such as retaining more natural teeth and enjoying better quality of life as a result—substantial challenges remain. Many older adults face significant obstacles to adequate oral health, including persistent inequities in oral health and access to care. In addition, the harmful effects of smoking, poor diet and food insecurity, increasing physical and cognitive impairment, medications that can cause dry mouth, and living with multiple chronic diseases can negatively impact oral health.

Four out of five older adults live with at least one chronic disease. Some common chronic conditions associated with inflammation, such as diabetes and cardiovascular disease, may have direct implications for the health of teeth and gums, and others, particularly degenerative and disabling ones such as Parkinson's and Alzheimer's disease, pose obstacles to maintaining good oral hygiene and receiving regular dental care. Conversely, untreated oral diseases can preclude, delay, or jeopardize numerous medical treatments.

Dental caries remains an almost universal experience for older adults, with no change in prevalence based on the reporting from the 2000 report on oral health (96% vs. 97%). However, untreated tooth decay in older adults has declined by 6%, from an estimated 28% to 22%. Unfortunately, untreated caries decreased only slightly for older adults living in poverty (48% to 43%), whereas the decrease was significant for more affluent older adults (21% to 14%). Importantly, this disparity was still greater for those 75 years and older. With nearly 1 in 10 older adults experiencing severe periodontitis, this disease remains an important public health problem that needs to be addressed. Older men, Hispanic and African American individuals, and those who are poor or who have fewer years of education are at increased risk for severe periodontitis.

The loss of all natural teeth, or edentulism, reduces quality of life because it potentially affects one's nutritional status and interferes with the ability to eat, speak, and feel comfortable around other people. Since the publication of the Surgeon General's report on oral health in 2000, edentulism has decreased from about 32% to 17% for adults ages 65 and older in the United States. Among adults 65–74 years of age, 13% are edentulous today, compared with 50% in the 1960s. Among older adults, those living in poverty are three times more likely to be edentulous than those who are nonpoor. Non-Hispanic Black older adults are twice as likely to be edentulous as non-Hispanic White or Mexican American older adults. The likelihood that older adults would have lost all of their teeth also varies by where they live in the United States. Edentulism rates differ greatly by state, ranging from 26% to just 6%.

On a more positive note, the proportion of older adults who have lost no teeth because of disease or injury has doubled during the last 2 decades, from about 6% to 13%. The percentage of those with a functional dentition (more than 20 teeth) also has increased, from 31% to 51%. Despite these improvements, disparities persist for this indicator. For older adults living in poverty, the prevalence of having a functional dentition increased from 15% to 25%, whereas prevalence increased from 42% to 62% for nonpoor older Americans.

Dental implant technology has markedly improved since the 2000 Surgeon General's report on oral health. Improved materials, procedures, and provider experience have resulted in success rates among the highest of any type of surgical implants. Because of improved durability, aesthetics, and support, dental implants are becoming the preferred treatment of choice for many older adults who can afford them. Since 2000, the prevalence of dental implants has increased sevenfold among adults 65 and older (from about 1% to more than 7%). Similarly, as the prevalence of dental implants has been increasing, there is concern that peri-implantitis (inflammation) is also increasing. This suggests a need for additional research to clarify the factors that contribute to peri-implantitis and identify procedures that can mitigate postoperative complications.

Many "baby boomers," those born from 1946 to 1964, will keep their teeth longer than any generation before, yet they continue to experience declines in oral health. Older adults experience socioeconomic-related inequities in tooth loss, untreated decay, periodontal diseases, oral cancer, and other oral diseases and conditions. Better access to oral health care improves health outcomes by detecting oral disorders sooner and identifying preventable risk factors. However, numerous challenges make better access difficult to achieve. In addition to economic barriers, older adults experience the same social disparities that affect other age groups—as well as age discrimination—sometimes on the basis of beliefs that older adults have few or no teeth and so do not require routine dental care. Despite higher expectations than ever before that one should maintain one's own natural teeth, society continues to accept declines in oral health related to aging and to make oral health care an elective, rather than a mandatory, part of overall health care.

Almost half of all older adults lack dental coverage, which can put their oral health at risk. Most lose employer-

provided dental coverage when they retire, and Medicare, the primary type of health insurance for millions of older Americans, only covers dental services in very limited circumstances. Some older adults now receive a dental benefit through the purchase of a Medicare Advantage plan. Enrollment in these plans has increased from about 7% to 22% during the last 2 decades, with 2 out of 3 enrollees in these plans having a dental benefit. Although some older adults may access dental benefits through Medicaid, the availability of such benefits varies among states, and many dentists don't accept Medicaid reimbursement. The result of this is that, during the past 20 years, older Americans have seen the highest increases in out-of-pocket dental expenditures.

Receiving appropriate oral health care can be especially difficult for older adults who are frail, disabled, homebound, or who reside in long-term care facilities. A coordinated team of caregivers is essential for properly addressing their care. Improving access to care requires an array of trained, community-based health providers and advocates who understand the importance of oral health, make appropriate referrals, and provide appropriate care for this population. Unless dental care is delivered in their homes, access may be a problem for frail or homebound elders. The issue becomes even more complex for people who live in rural or isolated areas where distances to access care are longer, and health networks and support services are scarce. During the past 20 years, substantial efforts to increase the integration of oral health services with primary health care—focusing on early intervention and prevention and using technology (for example, teledentistry)—has improved access to care for pediatric populations. Similar activities could benefit older adults.

Since the 2000 Surgeon General's report, promising new initiatives increasingly have focused on addressing shared risk factors and improving the management of noncommunicable diseases, improving interprofessional education and delivery of care, and identifying mechanisms to include oral health care as an integral part of our health care system (Box 2, Section 3B). These measures are critical in avoiding new and recurrent oral diseases, maintaining dignity and quality of life, and promoting improved general health and well-being during one's lifetime. Improving oral health and oral health care for older Americans through such efforts are achievable goals.

Section 4: Oral Health Integration, Workforce, and Practice

The U.S. oral health care system has experienced substantial changes in its workforce, education, practice, and financing. It has launched efforts to improve access to care for underserved populations, improve patient safety, and better integrate oral and general health care delivery. The oral health workforce consists of more than 750,000 dental professionals—including more than 200,000 dentists, 221,560 dental hygienists, 351,470 dental assistants, and other dental professionals working in private and public practices, academia, and federal-, state-, and local-government settings.

The Surgeon General's 2003 *National Call to Action to Promote Oral Health* emphasized the need for public-private partnerships to improve the oral health of all Americans and called for collaborative efforts to integrate general medical and oral health care. Many initiatives have been implemented during the past 2 decades to promote and support the integration of oral health and medical care, often with a substantial investment from HRSA to build the evidence base. Since then, models have emerged for multidisciplinary teams of health professionals to deliver oral health care in a variety of settings outside the dental office. These models usually seek to: (1) expand the number and type of patients who can obtain care, (2) improve patient outcomes, and (3) reduce the cost of care.

The movement toward integration of dental and medical services is an important strategy to increase access to care for underserved patients and to improve patient care delivery and outcomes while reducing costs. Public and private organizations have expanded interprofessional practice models to provide care to underserved populations. Commercial health systems and insurers have tested new models of integrated care delivery with the purpose of improving patient outcomes while reducing cost. Although full-scale integration of oral health, medical, and behavioral health has not yet occurred, some innovative strategies to address this goal have been launched. An important goal of integration and workforce expansion is to encourage each member of the dental team to work effectively within their respective licensing capabilities to maximize access to dental care.

Oral health integration within primary care medicine expands oral health care through the existing medical workforce, including pediatricians, nurse practitioners, and physician assistants. Providing oral health assessments and preventive care via primary medical providers can reach new patients and expand oral health capacity in areas where there are shortages of dental professionals. Some medical providers employ dental hygienists to deliver oral health screenings and services in medical offices for high-risk patients, in some states under physician supervision. Barriers to such practice integration remain, however, and changes are needed in federal and state licensing laws, along with payment reform, provider education, and information sharing to achieve optimal success.

Although there are more oral health providers in the United States than in 2000, about 60 million Americans live in areas (mostly rural) where there are too few dentists to meet local needs. Every region of the country has shortage areas, but rural areas account for more than two-thirds of these, and only about half of dental needs are being met for people in these areas. Some populations, such as those served by the Indian Health Service, have particularly acute shortages.

Today's oral health workforce includes not only dentists, but other oral health professionals such as dental therapists, public health dental hygienists, and community dental health coordinators (CDHCs). Non-dentist providers also expand care by offering oral health prevention and referral services in family or pediatric medical practices. Since 2000, professional education programs have expanded to include training for dental therapists, advanced-standing dental hygienists, and CDHCs. Enrollment in dental and allied education programs is at an all-time high. Racial and ethnic diversity within these professions is increasing modestly, and more than half of the most recent dental graduates are women. Nevertheless, underrepresentation continues to be a concern for some racial/ethnic groups within the oral health profession.

The high cost of dental education is one of several factors determining where graduates choose to practice. The average debt level in 2017 for students graduating from a private dental school was approximately $340,000, and from a public dental school, $240,000. Although dentists typically have the highest debt among major health professionals after completing dental school training, veterinary medicine (163%), optometry (130%), and pharmacy (111%) have higher debt-to-income ratios, compared to dentistry (99%). Dental education loan repayment and scholarship programs are important tools for enhancing workforce diversity. Numerous federal and state programs are available to reduce the high cost to the student of dental education, but it remains unclear whether debt deters underrepresented minorities and lower-income individuals from choosing dentistry as a career.

The most important change in the U.S. dental workforce since the 2000 report has focused on dental therapy. In 2004, the dental health aide therapist (DHAT) was introduced in Alaska when the first Alaska Native students graduated from a dental therapy program in New Zealand and returned home to address communities' oral health needs. Three years later, the Alaska Native Tribal Health Consortium opened a 2-year DHAT education program in partnership with the University of Washington School of Medicine's physician-assistant training program. In 2015, the program transferred its academic affiliation to Ilisaġvik College, a tribal college based in Alaska, and was renamed the Alaska Dental Therapy Educational Program. In 2020, the program became the first dental therapy educational program to receive accreditation from the Commission on Dental Accreditation. After 15 years of DHAT practice in Alaska, 74% of those trained were still practicing.

The first state to successfully add dental therapy to a practice act was Minnesota, in 2009. The resulting legislation allows for dental therapy practice of differing levels and includes a requirement for these therapists to practice under a dentist's supervision and to primarily serve low-income, uninsured, and underserved patients. Currently, all Minnesota dental therapy program graduates are eligible to practice both dental therapy and dental hygiene. As of 2019, there were 92 licensed dental therapists, with 95% working in their field. In addition to Minnesota, dental therapy has been authorized in Arizona, Connecticut, Maine, Michigan, New Mexico, Nevada, Oregon, and Vermont. Washington, Idaho, and Montana have authorized dental therapists to practice on tribal lands.

Solo, private dental practices have decreased as a percentage of all dental practices, with a commensurate increase in the number of group practices and corporate-owned practices during the past 20 years. However, about half of all dentists continue to work in solo dental practices. Most oral health care occurs in private dental offices, yet people increasingly receive care where they live, work, and learn—including in educational settings, community health centers, government-run clinics, dental schools, long-term care facilities, and mobile practices. Unfortunately, such opportunities are limited in many states by policies restricting scopes of practice and reimbursement for non-dentist providers who might otherwise be able to provide primary and secondary preventive services in those settings. In general, studies have shown that dental therapists can provide efficacious dental care benefiting underserved communities.

Government-owned or not-for-profit clinics provide safety nets for the country's underserved populations: the uninsured, Medicaid recipients, and other vulnerable populations who may not traditionally be well served in private dental practice settings. These practices include Federally Qualified Health Centers (FQHCs), community clinics, and dental school clinics. In 2020, >28.5 million patients received care from FQHCs with nearly 5.2 million receiving dental care. About 4 of every 5 community health centers provide dental services on site.

In addition to dentists in private practices who accept Medicaid and CHIP dental coverage, the dental safety net includes dental schools and education centers that train dentists, dental assistants, hygienists, and therapists. These academic institutions serve as dental care sites for those with Medicaid, CHIP, or no insurance. From 2016 to 2017, about 1 in 6 visits to dental students were provided outside the dental schools and in community settings.

From 2010 to 2017, the proportion of dentists in solo practices decreased from 56% to 51%, a trend most evident among dentists aged 35–44 (49% to 40%) and those younger than 35 (27% to 21%). Practice ownership also has declined, with 84% of dentists owning their practices in 2005, compared to 78% in 2017. The greatest decrease was for dentists under 35 (44% to 28%) (ADA News 2018). In contrast, group practice affiliation has been rising, with nearly 9% of U.S. dentists reporting an affiliation with a dental service organization; among dentists younger than 35, that share was even higher, at 18% (American Dental Association Health Policy Institute 2018).

A major change since the Surgeon General's report on oral health in 2000 has been the development of electronic dental records and the nascent integration of those electronic medical records into an integrated EHR. Commercial health systems, as well as some community-based health systems and federal providers of health care, such as the U.S. Department of Veterans Affairs, are taking advantage of clinic co-location to promote medical-dental integration, including a fully integrated EHR.

The development of safety and quality measures and dental diagnostic codes (in addition to procedure codes) will improve outcomes for oral health care. Because it lacks systematic terminology and coding infrastructure, dentistry has been limited in its ability to connect diagnosis to treatment, and thereby measure the quality and effectiveness of care in the ways that have occurred in medicine. Although academic institutions and some large group practices have adopted standard diagnostic terminologies, the vast majority of dental practices do not use them, and neither the dental insurance industry nor government funders request diagnostic codes. Connecting a diagnosis to treatment would improve the measurability of care provided and, ultimately, the quality of oral health care. The growing emphasis on quality metrics and value-based payments is prompting more emphasis on evidence-based practices, health literacy, patient-centered care, and population health outcomes.

Since 2000, a number of forces that affect oral health professionals have had an impact on the delivery of care to all Americans. Although the oral health workforce has expanded, there are still areas underserved by providers. The development of new types of providers, along with the integration of medical and dental services, are increasingly seen as the best solutions for addressing these needs. Other innovations to improve the capacity and effectiveness of the oral health workforce will involve adoption of integrated EHRs, along with the use of more efficacious coding for diagnoses and treatments, and the development of new models for reimbursement. The education of dental professionals will no doubt undergo

parallel changes to ensure that those who will provide care are ready to do so within a new environment. That environment will be more highly integrated with medical and behavioral health care, more attuned to new health and safety requirements, and more sharply focused on skills for serving the diverse health care needs of individuals from all sectors of our society. Key summary messages are presented in Box 5, Section 4.

Section 5: Pain, Mental Health, Substance Use, and Oral Health

During the past 2 decades, mental illness and substance use disorders (SUDs) have come to exceed physical health conditions as the more frequent causes of disability in the United States. Nearly 1 in 4 people in this country experience some form of mental illness, and 6.5% live with a severe mental illness. About 8% of American adults reported having an SUD in the past year; 3% reported illicit drug use disorder, and 6% an alcohol disorder. Currently, 9.5 million adults have co-occurring mental illness and SUD.

There are complex relationships between mental health and oral health. Patients with mental illness or substance use disorders often have difficulty maintaining an oral hygiene regimen or a relationship with an oral health provider. Dental or orofacial pain can worsen depression. Treating such pain, whether acute or chronic, with opioid-based pain medications can lead to dependence and a cycle of SUD. And substances associated with these disorders, including tobacco, cannabis, opioids, and methamphetamine, can cause or contribute to periodontal disease, caries, OPCs, and other oral health problems. Improving orofacial pain management and including oral health considerations in the treatment of mental illness and SUD are fundamental to improving both oral health and mental health services.

Furthermore, misuse of prescription opioids, addiction to these medications, and related overdose deaths continue to be a major public health concern. Nearly 50,000 Americans died from opioid overdoses in 2019, exceeding the annual number of casualties related to automobile and gun deaths combined. For many, particularly adolescents and young adults having wisdom tooth extractions, first-time exposure to opioids occurs in the context of oral surgery. Among dentists, the majority of new opioid prescriptions are written for teenage patients, putting them at risk for opioid dependence disorder. However, dental practitioners have made significant progress in changing their opioid prescribing practices during the last 20 years, including prescriptions for pain associated with oral surgery. In 1998, U.S. dentists were the most frequent specialty prescribers of fast-acting opioid prescriptions, accounting for 1 in 6 opioid prescriptions. By 2012, dentists prescribed about 1 in 15 of these types of medications.

Although dentists are prescribing fewer opioids for dental pain, opioid prescriptions remain high when patients seek care for a dental problem in hospital EDs. This appears to occur because symptom management, rather than definitive treatment, tends to be the goal for treating dental pain in these settings. People are up to five times more likely to receive opioid prescriptions for dental problems when they are treated in EDs rather than in dental offices.

In addition to the impact of substance use on overall health, many substances have direct consequences for oral health. Oral health also may be worsened by the direct effects of substances (licit or illicit) that patients use to cope with feelings of anxiety or depression. Some medications prescribed for the treatment of mental illness may have side effects, such as dry mouth, which compromise oral health. People with SUDs may neglect their oral health, often because they can't afford to seek dental care, and the substances they use may mask oral pain and cause them to ignore worsening symptoms.

Since the publication of the 2000 report on oral health, a new public health threat has emerged: e-cigarette use, which entered the U.S. market in 2006. This risk is most concerning for teenagers because the use of e-cigarettes has drastically increased in the past decade. For example, between 2011 and 2018, e-cigarette use increased from 1.5% to 27.5% among U.S. high school students and from 0.6% to 10.5% among middle school students, leading the U.S. Surgeon General to declare youth e-cigarette use an epidemic in 2018. During 2020, approximately 1 in 5 high school students (3.02 million) and 1 in 20 middle school students (550,000) currently used e-cigarettes. Touted early on as an aid to smoking cessation, with emphasis on harm reduction, this has not turned out to be the case. And, in fact, adolescents who use e-cigarettes may be

more likely to smoke cigarettes in the future and may have increased risk for future addiction to other drugs.

Early research on e-cigarette use shows that it has many of the same negative effects on gums and other oral cavity tissues that are seen with other tobacco product use. The use of tobacco products has known oral health risks, including periodontal disease and oropharyngeal cancer. By more actively engaging with their patients in tobacco-cessation practices and counseling programs, oral health professionals can substantially reduce the risk of these diseases.

Given the increasing legalization of recreational use of marijuana in the United States, there is growing concern about its impact on oral health. Cannabis use is associated with reduced salivary flow, and some associations have been found with higher levels of decay and gum disease. Because these effects often are compounded by tobacco use, research is needed to refine the specific effects of cannabis on oral health.

During the past 20 years, we have significantly improved our understanding of the long-term consequences of methamphetamine misuse. Methamphetamine has devastating oral health consequences related to severe impairment of salivary flow, resulting in extensive tooth decay, broken teeth, and diseased gums, as well as serious consequences for overall health. The pattern of severe dental caries involving the smooth surfaces of all or most of the front teeth is a hallmark of chronic methamphetamine use and has given rise to the moniker "meth mouth."

There is growing evidence of a strong association between psychiatric disorders and poor oral health, although the patterns and severity of dental disease vary. For instance, people with schizophrenia, other psychoses, and bipolar affective disorder have particularly high rates of gum disease and decay; they are three times more likely than the general population to have lost all of their teeth. People with psychiatric disorders also have higher rates of tooth loss and erosion because of mechanical forces such as bruxism, as well as loss of tooth structure resulting from the chemical activity of acidic drinks, gastric reflux, or frequent vomiting.

In identifying major themes arising from this section of the report, we first note that the relationships of oral health to mental health and issues of substance use have not been well investigated. Furthermore, oral health providers often have no information about a patient's mental health status or issues with substance use. The absence of shared information systems between dentistry and medicine in support of clinical decision making for patients with dental pain, mental health disorders, and SUDs is a critical shortcoming. In situations where comorbidities can determine health outcomes, integrated health records become essential for providing person-centered care. Notwithstanding this context, oral health care providers are well positioned both to identify symptoms and to provide support for addressing problems of substance use. Ensuring that they are prepared to offer the support that is needed means including mental health and substance use in the curricula for training oral health professionals. Similar attention needs to be given to education related to mental health and its impact on oral health. Box 7, Section 5 presents key messages addressing issues related to pain, mental illness, substance use disorder, and oral health.

Section 6: Emerging Science and Promising Technologies to Transform Oral Health

The prospect of improving human health depends upon strategic scientific investments, new biologic discoveries, and technologic advancements. Science and technology provide the essential foundation for preventing and treating oral disease, and research breakthroughs during the past 20 years offer exciting opportunities to improve oral health. New discoveries also make it clear that oral health is inextricably bound with health in general; diseases in other parts of the body can cause or exacerbate oral disease, and vice versa. Although this connection has long been recognized, our understanding of it deepens with every discovery. As scientists are identifying mechanisms of oral disease, enabling fresh views of previously held beliefs and creating extraordinary tools for diagnosis and treatment, new technologies and scientific approaches must be adapted to dental and medical practices in ways that are well thought out, evidence-based, and available and accessible to all.

Tremendous advances have occurred in the technology supporting dental practice, including new, bio-inspired dental materials, innovative chairside diagnostic strategies, 3D bioprinting, and improved digital imaging.

The development of durable and highly aesthetic biomaterials has revolutionized the replacement of broken and severely decayed teeth. Custom-made implants and dentures can be made available to all as the 3D printing technology to produce them improves and becomes less expensive, and as materials are developed that are suitable for use with 3D printing technology.

Discoveries related to the microbiome, genomics, and other "omics" offer promise for individualizing oral health care and revealing relationships among systemic diseases, suggesting possibilities for new treatments. In 2003, the Human Genome Project sequenced the entire human genome and accelerated gene mapping for complex traits that comprise oral and craniofacial conditions. The ability to analyze different cell populations at the single-cell level has furthered our understanding of variations among same cell types. This development creates the potential to analyze illnesses at the cellular and molecular level and devise unique treatments designed to match individual genetic profiles within the context of environmental influences.

Discoveries in cellular analyses and regenerative medicine are leading to new treatments to improve oral health, including techniques and products created for bone and soft tissue regeneration that currently are being used in clinical settings. The identification of mesenchymal stem cells (stem cells found in skeletal and oral tissues that can be used to make or repair craniofacial anomalies or damage) holds enormous promise for therapeutic applications.

Not only have substantial advances in genomics expanded our knowledge of factors affecting oral health during the past 20 years, but new discoveries bridging microbiology and genetics have provided novel opportunities to better understand the important role of bacteria in health and disease. The oral microbiome is now known to be a diverse collection of hundreds of distinct bacterial species, and its relationship with other microbiomes in the body is in the very early stages of study. Research on the "inflammasome"—a network of proteins that regulates inflammation—may transform the treatment of periodontal disease and other oral diseases involving inflammation. Underlying genetic mutations have been identified for several dental conditions, and dental genetic variants also have been associated with more severe conditions.

Implementation science, the discipline of taking new discoveries out of the lab and incorporating them into daily practice, holds promise for more effective adoption of evidence-based oral health practices, reduction of oral health disparities, and improvement of oral health equity.

Novel ways to collect data at home will allow investigators to see patterns over time and to measure the safety and effectiveness of new technologies or oral health interventions in the real world. This capability already exists for sensor-enabled electric toothbrush systems that convert simple oral hygiene tools into smart devices to collect information. For example, toothbrushing frequency, duration, and tooth coverage are all measurable with increasing accuracy.

Digital platforms supporting telehealth and teledentistry are continuing to improve, making use of this technology more common in dental practice. The expanding use of teledentistry also will continue to improve access to oral health services, especially for Americans living in more remote parts of the country. Unfortunately, other digital platforms employed in support of an integrated EHR have lagged in development by comparison, and renewed investment is needed to facilitate improvements. The availability of fully integrated EHRs will make it much easier for health care providers to understand a patient's health and history, leading to fewer errors and higher-quality care.

The field of data science has grown considerably during the past 20 years, offering improved opportunities in "big data" analytics using integrated EHRs and other large health databases for analyses as computing power has become more robust and efficient. The opportunities for oral health are enormous; for example, at the level of the dental office, practitioners would be able to access a summary view of their entire practice population, including information on medical conditions, age, gender, tobacco use, and socioeconomic factors that might affect their need for dental care. The practice will use its data to identify trends, set goals, and track improvements. Public health researchers will do the same analyses in a community, statewide, or nationally, identifying specific populations or areas in need of oral health resources and

creating a "learning health system" for oral health services. Since the release of the Surgeon General's report on oral health 20 years ago, technology advancements for practice and data science advances are helping to improve clinical decision making and advance public health in ways that improve understanding of the health of the whole person, as well as the health of a population (see Box 2, Section 6 for key messages).

Summary and Call to Action

This report, *Oral Health in America: Advances and Challenges*, examines the status, opportunities, and challenges for oral health in the context of today's major societal problems, including substance use disorders, the opioid epidemic, and mental health concerns, as well as the use of tobacco, alcohol, and other behaviors that can carry oral health risks. Equally important, the impact of the ongoing coronavirus pandemic on oral health is considered, along with the possibility of other, still-unanticipated public health threats. Just as these health challenges impact oral health, the social and cultural problems of our day are inextricably related to issues of oral health. The improvement of our nation's oral health will depend on our ability to address this full array of determinants. Just as the 2000 Surgeon General's report on oral health in America shaped the thinking of researchers, practitioners, and patients during the last 2 decades, we expect that this report will set new directions and energize an era of seeking better oral health for all. Ultimately, these efforts will help to create a new understanding of the value of oral health – one that is based not just on the well-being of individuals, but also on the health and productivity of our nation as a whole.

The future for oral health in America is promising, and it depends on our ability to expand and implement the view that oral health is an essential part of overall health and health care. This report has outlined three important areas where action could be undertaken to accomplish that task and substantially improve oral health in this country. First, dental and other health care professionals must work together to provide integrated oral, medical, and behavioral health care in schools, community health centers, nursing homes, and medical care settings, as well as dental clinics. Second, we need to diversify the composition of the nation's oral health professionals, address the costs of educating and training the next generation, and ensure a strong research enterprise dedicated to improving oral health. Finally, to reduce or eliminate social, economic, and other systemic inequities that affect oral health and access to care, policy changes also are needed (Box). Steps taken during the last 2 decades have demonstrated some important potential paths forward, and the collective actions we take today can ensure that everyone in this country has the opportunity to enjoy the benefits of good oral health tomorrow.

Box. Key summary messages for *Oral Health in America: Advances and Challenges*

- Good oral health is important for the overall health and well-being of individuals of all ages, their families, communities, and the nation.
- Through research and policy changes over the past 20 years, we have made substantial advances in the understanding and treatment of oral diseases and conditions, yet many people of all ages and demographic backgrounds still have chronic oral health problems and lack access to care.
- Healthy behaviors can improve and maintain individuals' oral health; these behaviors are shaped by social and economic conditions in which people are born, grow, work, and live.
- Oral and medical conditions often share common risk factors, and just as medical conditions and their treatments can influence oral health, so can oral conditions and their treatments affect other health issues.
- Substance misuse and mental health conditions negatively affect the oral health of many, and oral health providers are an integral part of the interprofessional team caring for these individuals. Professional schools have been challenged in preparing dental providers with the knowledge and skills needed for these new roles.
- Oral health services are evolving rapidly towards interprofessional models of delivery that integrate services across the health professions and expand access to care through new practice settings and new professional roles.
- The COVID-19 public health crisis has challenged the nation's health care system, including oral health care providers as never before, and with those challenges came new ways of ensuring safety during provision of dental care, of treating disease, and recognizing that oral health cannot be separated from overall health.

Call to Action:

- To significantly improve the nation's oral health, policy changes are needed to reduce or eliminate social, economic, and other systemic inequities that affect oral health behaviors and access to care.
- To improve oral health for more people, dental and other health care professionals must work together to provide integrated oral, medical, and behavioral health care in schools, community health centers, nursing homes, and medical care settings, as well as dental clinics.
- To strengthen the oral health workforce, we need to diversify the composition of the nation's oral health professionals, address the costs of educating and training the next generation, and ensure a strong research enterprise dedicated to improving oral health.

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