ANNUAL REVIEWS

Annual Review of Public Health

Disparities in Access to Oral Health Care

Mary E. Northridge,[1,2] Anjali Kumar,[1] and Raghbir Kaur[1]

[1]NYU Langone Dental Medicine–Brooklyn, Postdoctoral Residency Program, Brooklyn, New York 11220, USA; email: Mary.Northridge@nyulangone.org, Anjali.Kumar@nyulangone.org, Raghbir.Kaur@nyulangone.org

[2]Hansjörg Wyss Department of Plastic Surgery, NYU School of Medicine, Brooklyn, New York 11220, USA

Annu. Rev. Public Health 2020. 41:513–35

First published as a Review in Advance on January 3, 2020

The *Annual Review of Public Health* is online at publhealth.annualreviews.org

https://doi.org/10.1146/annurev-publhealth-040119-094318

Keywords

interventions to reduce disparities, oral health care equity, disadvantaged populations, oral disease prevention, dental services, life course approach

Abstract

In the United States, people are more likely to have poor oral health if they are low-income, uninsured, and/or members of racial/ethnic minority, immigrant, or rural populations who have suboptimal access to quality oral health care. As a result, poor oral health serves as the national symbol of social inequality. There is increasing recognition among those in public health that oral diseases such as dental caries and periodontal disease and general health conditions such as obesity and diabetes are closely linked by sharing common risk factors, including excess sugar consumption and tobacco use, as well as underlying infection and inflammatory pathways. Hence, efforts to integrate oral health and primary health care, incorporate interventions at multiple levels to improve access to and quality of services, and create health care teams that provide patient-centered care in both safety net clinics and community settings may narrow the gaps in access to oral health care across the life course.

1. INTRODUCTION

The title of this review is key to understanding its scope. The importance of oral health cannot be overstated for physical, emotional, psychological, and socioeconomic well-being, not only at the individual level but also at the interpersonal (e.g., family, friends), community, and societal levels (48, 89, 104, 130). Disparities in oral health care are differences that are both unnecessary and avoidable and also considered unfair and unjust (16, 17, 132, 146, 147; see the sidebar titled Oral Health Care Disparities and Equity in Oral Health Care).

While the imperative to eliminate disparities in oral health has long been recognized (65, 66, 132), the vital role of access to quality oral health care for people who are low-income, uninsured, and/or members of racial/ethnic minority, immigrant, or rural populations has heretofore received insufficient attention in the public health literature (23, 37, 77, 129). Disparities need to be more fully investigated in all aspects of oral health care, including the allocation of resources for oral health care (11, 66), the actual receipt (utilization) of oral health care services (95, 139), the quality of oral health care services (31, 32, 34), the oral health care workforce (90, 125), and the financing of oral health care, particularly with respect to the burden of payment on individuals and households (9, 65, 66, 132, 138, 142).

Community water fluoridation is rightfully considered one of the greatest disease-preventive measures of the twentieth century (25, 63, 91). Nevertheless, the US oral health care delivery system has failed to protect vulnerable populations from dental caries (i.e., tooth decay or cavities) and periodontal disease (i.e., an inflammatory condition that affects the soft and hard tissues that support the teeth), which consistently remain among the most prevalent of all chronic diseases over time, despite being largely preventable (65, 66, 89). Moreover, the incidence of oropharyngeal cancer related to infection with human papillomavirus (HPV) is rising, making it now the most common HPV-related malignancy in the United States, with no approved approaches for prevention and early detection of the disease (126).

This review is restricted largely to the United States, as the historical and continued separation of the oral health care delivery system from the medical care delivery system in this country is comprehensive and reinforced by the fact that dentists, dental hygienists, and dental assistants are separated from other health care professionals in virtually every way: where they are trained, how their services are reimbursed, and where they provide oral health care (13, 96; see the sidebar titled Oral Health Services Provision Worldwide).

Moreover, this history forms the background of current disparities and thus is briefly reviewed next (89). Then, a conceptual model for understanding factors that influence disparities in access to care and quality of health care services, by level, is presented (115), along with applications to oral health care per se (44, 58, 98, 101). The following section introduces the life course perspective (14, 15), which serves as an organizing framework for the subsequent section that details strategies to reduce disparities in access to oral health care from pregnancy through older adulthood (99).

ORAL HEALTH CARE DISPARITIES AND EQUITY IN ORAL HEALTH CARE

Oral health care disparities reflect unequal opportunities to be healthy, making disadvantaged groups even more disadvantaged with respect to their oral health; correspondingly, reducing oral health care disparities means giving disadvantaged social groups equal opportunities to be healthy. Pursuing equity in oral health care means pursuing the elimination of oral health care disparities, that is, equal access to available care for equal need, equal utilization for equal need, and equal quality of care for all.

ORAL HEALTH SERVICES PROVISION WORLDWIDE

According to the World Health Organization (WHO), oral health services provision coincides with the general trend in health services reform to ensure "health for all" through primary health care. In several Western industrialized countries, oral health services are made available to the population, comprise preventive and treatment services, and are based on either private or public systems. Meanwhile, people in deprived communities, racial/ethnic minorities, homeless people, homebound or disabled individuals, and older adults are not sufficiently covered by oral health care. In countries of Central and Eastern Europe, decentralization and deregulation of oral health services has taken place during recent years. With privatization, growing numbers of people cannot afford private dental care. In some Eastern European countries, third-party payment systems have been introduced, but priority is not given to preventive oral care. The demand for treatment services has increased, particularly for low-income groups. In addition, many children are not covered by oral health programs because the school dental services formerly offered in most Eastern European countries have been discontinued. In developing countries, oral health services are offered mostly from regional or central hospitals in urban centers, and little, if any, priority is given to preventive or restorative dental care. Many countries in Africa, Asia, and Latin America have a shortage of oral health personnel, and the capacity of the systems is limited largely to pain relief or emergency care. In Africa, the dentist to population ratio is 1:150,000 compared with 1:2,000 in most industrialized countries.

The challenge of creating an integrated system of oral health and primary care delivery with a focus on equity of services is then critically considered (13), along with the policy implications to address this challenge that would entail in the US context (89). The concluding section reaffirms previous calls to action for public health to claim oral health care as a social justice issue that merits concerted programmatic, research, and health policy support (128, 130, 133).

2. SEPARATE SYSTEMS OF ORAL HEALTH AND MEDICAL CARE PROVISION

Leading up to the professionalization of US dentistry in the mid-nineteenth century, at various times oral health care services had been rendered by physicians, surgeons, and artisans, with titles such as barber surgeon, toothdrawer, operator for the teeth, and surgeon dentist (86, 87). Because dentistry was not recognized during the establishment of US medical schools, the Baltimore College of Dental Surgery (now the University of Maryland School of Dentistry) was founded as an independent institution in 1840 (87). The 1926 Gies Report further solidified the development of US dentistry as an autonomous field, albeit one that was heavily patterned after medicine and often academically colocated (54, 89). In the ensuing years, medicine has played a dominant role in the development of health policy and practice in the United States, and oral health care is usually excluded or not considered part of primary health care, especially for adults (8, 137, 138).

Several constructively critical accounts have documented the consequences of the separate systems of oral health and medical care provision in the United States on disparities in access to even basic services for impoverished and underserved population groups compared with their more socioeconomically advantaged counterparts (13, 89, 124, 128). In essence, the current US oral health care delivery system may be considered as consisting of two tiers: (*a*) a loosely organized network of private practices; and (*b*) the oral health care safety net (65, 66, 128, 137). The network of primary practices consists primarily of solo and small group practices and serves about two-thirds of the US population, most of which has at least limited commercial dental benefits or partial ability

to pay for out-of-pocket oral health care expenses (6, 138). Note that most commercial dental insurance plans, which are largely employer-provided benefits, have high coinsurance rates and annual maximum benefit limits that, when adjusted for inflation, have decreased substantially over time (138). As a result, out-of-pocket spending accounts for a much higher share of oral health care spending than general health care spending (138). The oral health care safety net is expected to cover the remaining one-third of the US population, notably those who are low-income, uninsured, and/or members of racial/ethnic minority, immigrant, rural, and other underserved groups (50, 62, 137, 144). The safety net is composed of providers, payment programs, and facilities that provide clinical, nonclinical, and support services, including Medicaid and the State Children's Health Insurance Program (SCHIP), Federally Qualified Health Centers (FQHCs), school-based health centers, and academic dental institutions, among other entities (65, 66, 128). Nonetheless, adult oral health care benefits are optional under federal Medicaid law and are not included among the essential health benefits for newly eligible adults under the Affordable Care Act (ACA). As a result, Medicaid adult oral health care coverage varies tremendously across states and is limited in many states to emergency services such as tooth extractions or to specific populations such as pregnant women (109). Because oral health care is expensive, few Medicaid beneficiaries can afford to pay for dental services out of pocket (27, 109).

For the purposes of this review, this brief history is intended to underscore the role of structural determinants in creating and maintaining disparities in access to oral health care that result from the largely nonintersecting education, financing, and delivery systems of dentistry and medicine (89). State practice acts, standards of care, and professional school curricula all support this historical separation (80). As a result, the lack of infrastructure, technology, and personnel required to connect these separate systems often means that patients with limited economic means, health literacy skills, and psychosocial resources must navigate the dental/medical divide on their own (13, 33, 52, 76, 84, 123). Substantial legal, regulatory, and training barriers concurrently stand in the way of supporting dental providers to provide more primary health care services, medical providers to provide more oral health care services, and both groups of professionals to efficiently and effectively collaborate to improve patient care (80).

In the following section, we present a conceptual model intended to guide efforts to close the gaps in health disparities, interventions, and research (115). In concert with the public health perspective of this review, the present model was adapted from an ecological model on health behavior and education (120) and based on an analysis of findings from systematic reviews of cardiovascular disease and cancer disparities (28, 36, 56, 57, 94). Nevertheless, it has also proved useful in contextualizing multilevel influences on oral health disparities, their intervention targets, and the key stakeholders and outcomes that are affected by the devised interventions (44, 58, 97–100, 102).

3. CONCEPTUAL MODEL FOR CLOSING GAPS IN HEALTH CARE DISPARITIES

Factors that influence disparities in access to care and quality of health care services, by level, are presented in **Figure 1**. Although this conceptual model is necessarily a simplification of complex factors that influence such disparities, it belongs to a class of ecological models that are in widespread use and which posit that determinants at various levels influence health and health care (88, 104). The four levels of influence explicated in **Figure 1** are individual patient (level 1); family, friends, and social support (level 2); organization and provider (level 3); and policy and community (level 4). The associated intervention targets at each of these levels are then identified, including patient programs and services, insurance and affordability, and provider- and system-level supports

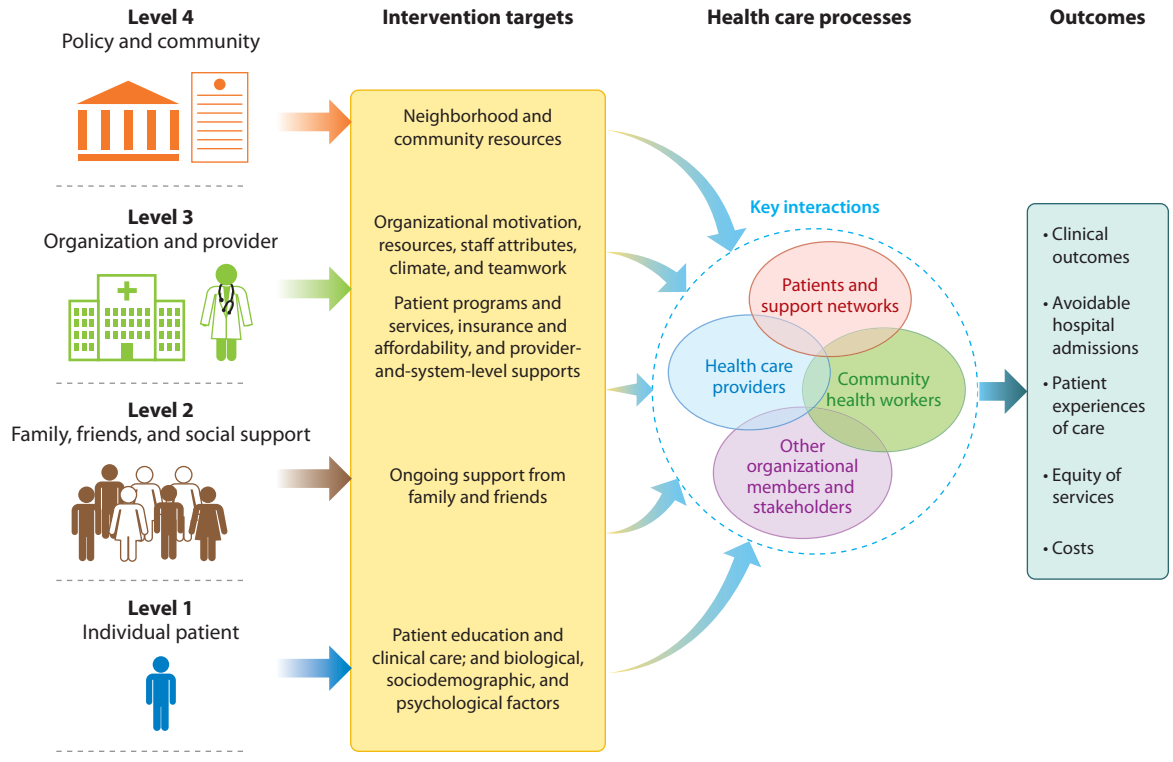

Figure 1

This conceptual model, factors that influence disparities in access to care and quality of health care services, by level, was created from the analysis of findings from systematic reviews of cardiovascular disease and cancer disparities (115). Figure adapted from Reference 115 with permission.

at the organization and provider level, which are especially pertinent to this review. Health care processes are subsequently distinguished, namely, interactions among patients and support networks, health care providers, community health workers, and other organizational members and stakeholders. Finally, the outcomes of interest are listed as follows: clinical outcomes, avoidable hospital admissions, patient experiences of care, equity of services, and costs.

A qualitative study utilizing focus groups conducted with African American, Puerto Rican, and Dominican older adults who attend senior centers in northern Manhattan, New York City, indicated that all four of these levels are indeed salient to oral health care (103). Regarding the acceptability of screening for hypertension and diabetes in the dental setting at the individual patient level, a focus group participant explained, "It would solve a problem, because that way the dentist would know my sugar level and blood pressure in order to work on me. . .it should be obligatory" (58, p. 348). In terms of the attempts made to influence the oral health of children and grandchildren at the family, friends, and social support level, an older adult shared, "I tell my grandkids you don't want to be like grandma. Keep, take care, brush your teeth, brush the tongue, the top of the mouth" (102, p. 545). The importance of factors at the organization and provider level was underscored by the largely positive experiences of racial/ethnic minority senior center attendees with the oral health care they received at dental schools, including the following observation: "If you go down to [New York University] dental school, you'll be surprised. You get beautiful teeth down there" (101, p. 1278). Finally, at the policy and community level, racial/ethnic

minority older adults were concerned about proposed Medicaid reforms and their potential effects on oral health care access, as evidenced by the following remarks of one senior center attendee: "We shouldn't have to have discussions about senior health. This should have been a foregone conclusion years ago. All that's been happening is that stuff has been taken away from us. It's made it more difficult for us to live like decent human beings" (98, p. S69).

Of critical importance, interventions that address factors at multiple levels of **Figure 1** may be more effective than those that target only a single level (110). With regard to the salience of addressing multiple levels for oral health care, a feasibility and acceptability study of a multilevel intervention in urban outreach centers to improve the oral health of low-income Chinese Americans includes a community health worker approach to oral health promotion and systems science modeling to understand dynamic complexity regarding the interplay of factors at all four levels and resultant influences on oral health care disparities (100). Systems science modeling methods lend themselves to a participatory and robust evaluation of whether this multilevel intervention results in improved oral hygiene knowledge and behaviors at the individual patient level; enhanced access to oral health care through encouragement and instrumental assistance at the family, friends, and social support level; more effective teamwork among administrators, staff, and dental and medical professionals at the organization and provider level; and ultimately, greater awareness of the importance of oral health and health care among low-income Chinese Americans at the policy and community level.

Note that the factors presented in **Figure 1** that influence disparities in access to care and quality of health care services operate across the life course, beginning during pregnancy and extending through the end of life. In the next section, the life course perspective on oral health promotion is introduced, followed by a subsequent section on targeted strategies that may effectively reduce disparities in access to oral health care at key stages throughout the life course.

4. LIFE COURSE PERSPECTIVE ON ORAL HEALTH PROMOTION

The life course approach is the study of long-term effects on chronic disease risk of physical and social exposures during gestation, childhood, adolescence, young adulthood, and later adult life (14). In disadvantaged populations and underserved communities, oral disease risk is elevated throughout the life course owing to, e.g., socioeconomic status, discrimination, and lack of eligibility and/or high out-of-pocket costs for public and private insurance coverage (9, 12, 19, 97, 99, 116). In particular, exposures that are patterned by social factors include poor nutrition, lack of preventive primary and oral health care (including vaccination against HPV), inferior quality of restorative oral health care (31, 34), violence and injury leading to face trauma, and excessive alcohol and tobacco use, all of which may affect teeth and their supporting structures, leading to dental caries (beginning in early childhood), oropharyngeal cancer (currently an epidemic among younger men), periodontal disease (highly prevalent with increasing age), oral cancers (especially in older men), and eventually root caries and tooth loss (particularly in older adults).

A simplified graphic that illustrates the life course approach to oral health promotion, beginning in infancy and moving through older adulthood, is presented as **Figure 2** below (15). **Figure 2** focuses on the developing dentition (i.e., the arrangement or condition of the teeth) in the upper panel and on the oral health promotion behaviors in the lower panel that are beneficial at each stage of the life course. At both the population and individual levels, these behaviors are structured and patterned by the social and cultural determinants of oral health, including education, employment, working conditions, occupation, income, housing, and culturally appropriate, affordable, and acceptable prevention and treatment services (111, 127, 140, 141).

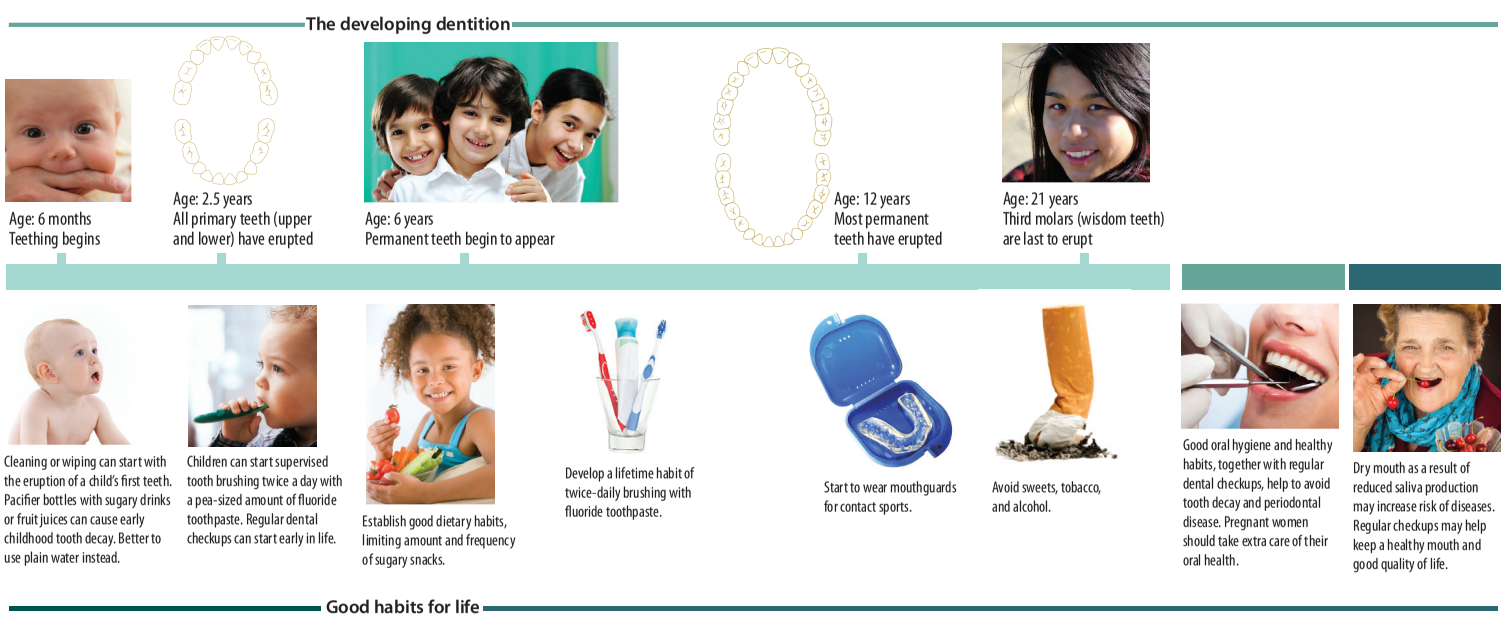

Figure 2

This graphic of the life course perspective begins in infancy and moves through older adulthood, focusing on health behaviors at critical periods that foster oral and craniofacial health (15). Figure adapted from Reference 15 with permission.

CARIES AND PRESERVATION OF TOOTH STRUCTURE

The major outcome of caries prevention and management at the individual patient, organization and provider, and policy and community levels ought to be the preservation of tooth structure and maintenance of teeth in a healthy state. Access to primary oral health care and application of topical fluoride, pit and fissure sealants, and silver diamine fluoride can control initial stages and arrest the progression of caries or reverse the caries process toward health. Unfortunately, surgical restoration of lost tooth structure and function of decayed teeth with artificial materials remains the dominant practice model. Instead, health outcomes should form the basis for compensation and become the focus of oral health care. New tools such as the use of computerized reminders, electronic audit and feedback, and stop-and-go decision algorithms in electronic health records can aid and empower changes to norms of practice and the collection of outcome data.

4.1. Universal and Targeted General and Oral Health Interventions

Certain interventions are important for oral health per se, such as efforts to promote the use of affordable and effective fluoride in its various forms and strategies to improve access to primary oral health care to better preserve tooth structure and maintain teeth in a healthy state (15, 96, 114; see the sidebar titled Caries and Preservation of Tooth Structure).

Other interventions, however, are important in promoting both general and oral health. For instance, a primary cause of dental caries is repeated conditions of acidity in the oral cavity (82), including through the intake of frequent sugary snacks (21, 93, 114). Thus, limiting sweets as part of a healthy diet through interventions at all levels of **Figure 1** promotes better oral health and may also reduce the incidence of obesity, diabetes, and related health conditions (15, 96, 143).

4.2. Trajectories of Oral Health Development

In reality, orofacial growth and development are complex processes that begin during gestation and span the life course (18, 45, 107). In this review, the focus is on access to oral health care, which may change the trajectories of oral health development for individuals and populations (60). Note that health trajectories are not necessarily straight, linear, overly determined, or immutable but can be in a constant state of flux relative to different influences at various points in time and, thus, are amenable to intervention (60).

Next, we review evidence-based strategies that are practical and potentially scalable and that hold promise in reducing disparities in access to oral health care at important stages of the life course. In the end, programs that couple universal population-level strategies, such as those presented in **Figure 2**, with targeted approaches for at-risk groups, including those reviewed next, are expected to add meaningful value to current efforts to advance oral health care equity (115).

5. REDUCING DISPARITIES IN ACCESS THROUGHOUT THE LIFE COURSE

Both oral and general health conditions may be improved by regular dental visits (65, 66, 78, 132). Accordingly, a Healthy People 2020 Leading Health Indicator (meaning that it is a high-priority health issue) is OH-7: increase the proportion of children, adolescents, and adults who used the oral health care system in the past year (105). The 2020 target for OH-7 is 49%, but the 2015 Medical Expenditure Panel Survey (MEPS) documented continuing disparities by poverty level (28% poor, 32% low income, 39% middle income, and 55% high income), race/ethnicity (30%

non-Hispanic Black, 33% Hispanic, and 49% non-Hispanic White), and dental insurance (20% none, 33% public, and 56% private) (81). This section reviews the major oral health conditions at each stage of the life course and evidence-based strategies that may be scaled up toward reducing disparities in access to oral health care.

5.1. Pregnancy

5.1.1. Oral health conditions during pregnancy. In 2012, the Oral Health Care During Pregnancy Expert Workgroup underscored the importance of the provision of oral health care to pregnant women in an accessible report titled *Oral Health During Pregnancy: A National Consensus Statement* (61, 106). Convened by the Maternal and Child Health Bureau of the Health Resources and Services Administration (HRSA), both dental and medical professionals stressed that preventive, diagnostic, and restorative dental treatment is safe throughout pregnancy and effective in improving and maintaining oral health (106).

During pregnancy, shifts in hormonal, immunologic, and vascular function can exacerbate gingival inflammation and increase susceptibility to periodontal disease (7, 73). Emerging evidence suggests that there is a dynamic complexity to the oral microbiome that provides important benefits to the host, including immunological priming, downregulation of excessive proinflammatory responses, regulation of gastrointestinal and cardiovascular systems, and colonization by exogenous microbes (83). Physiological disruptions to this finely tuned equilibrium at various stages throughout the life course, including during puberty and pregnancy, may allow disease-promoting bacteria to manifest and cause conditions such as caries, gingivitis, and periodontal disease (69; see the sidebar titled The Oral Microbiome in Health and Disease).

Socioeconomic disparities across clinical oral health indices exist among pregnant women, and extensive problems have been documented among lower-socioeconomic-status women while pregnant and postpartum (47, 75, 117).

5.1.2. Targeted interventions to reduce disparities in access to oral health care during pregnancy. While salient across all stages of the life course, the integration of care in safety net settings is best instituted as early as possible, including during pregnancy for the developing fetus. In 2014, the HRSA released the report *Integration of Oral Health and Primary Care Practice*, which outlined interprofessional oral health core clinical competencies appropriate for primary care providers who practice in safety net settings, including nurse practitioners, nurse midwives, physicians, and physician assistants (134). These frontline primary care practitioners are the most likely to care for vulnerable and underserved populations with no or limited access to oral health care

THE ORAL MICROBIOME IN HEALTH AND DISEASE

The mouth is home to the second most diverse microbial community in the body; more than 700 species of bacteria colonize the hard surfaces of the teeth and the soft tissues of the oral mucosa. The complex equilibrium between resident species in the oral cavity is responsible for the maintenance of a healthy state (symbiosis) or a state associated with disease (dysbiosis). In health, most of the bacteria have a symbiotic relationship with the host. Potentially cariogenic or periodontopathic bacteria have been detected at healthy sites at low levels that are not clinically relevant; they may also be acquired from close partners (transmission), but again, their levels would be extremely low relative to the bacteria associated with health. In disease, there is an increase in the numbers and proportions of cariogenic or periodontopathic bacteria, and there may be increased biomass (especially in gingivitis).

RECOMMENDATIONS FOR AN INTERPROFESSIONAL PRACTICE MODEL

The Health Resources and Services Administration (HRSA) synthesized recommendations and considered expert and professional opinions expressed during the Integration of Oral Health Care and Primary Care Practice meetings. The following recommendations serve as guiding principles and provide a framework for the design of a competency-based, interprofessional practice model to integrate oral health and primary care.

1. Apply oral health core clinical competencies within primary care practices to increase oral health care access for safety net populations in the United States.
2. Develop infrastructure that is interoperable and accessible across clinical settings and enhances adoption of the oral health core clinical competencies. The defined, essential elements of the oral health core clinical competencies should be used to inform decision making and measure health outcomes.
3. Modify payment policies to efficiently address the costs of implementing oral health competencies and provide incentives to health care systems and practitioners.
4. Execute programs to develop and evaluate implementation strategies of the oral health core clinical competencies into primary care practice.

services, and they could incorporate oral health core clinical competencies into their existing scope of practice (134; see the sidebar titled Recommendations for an Interprofessional Practice Model).

Medicaid benefits for reproductive care, including both maternity care and family-planning services, are critically important for low-income women, who make up two-thirds of nonelderly adult enrollees (109). While the ACA did not affect Medicaid eligibility for pregnant women per se, since they were already eligible, Medicaid coverage expansion in 37 states and Washington, DC, under the ACA offers more continuous Medicaid eligibility to women who previously would have lost coverage after the postpartum period (119). As mentioned previously, adult dental benefits are optional Medicaid services on a state-by-state basis and are not part of the essential health benefits requirement under the ACA (64). Hence, research and policy solutions to expand the scope of Medicaid coverage coupled with safety net collaborations hold the greatest short-term potential to improve access to oral health care for not only considerable numbers of low-income pregnant women, but also other low-income adults in vital need of services (134, 135).

5.2. Infancy and Childhood

5.2.1. Oral health conditions during infancy and childhood. Along with the critical focus on providing pregnant women with oral health care, maternal oral health is related to infant oral health both biologically and behaviorally (47, 64, 107, 122). The same microbes found in the oral cavity of the mother have also been found in the amniotic fluid and the placenta and may contribute to adverse pregnancy outcomes (30, 51, 136). Maternal salivary bacterial challenge is associated with oral infection among children and predicts increased incidence of early childhood caries (ECC) (26). Prenatal smoking, higher prepregnancy weight, and lack of first-trimester prenatal care have been associated with enamel defects and caries in children (47, 67, 68).

The period from birth through 3 years of age is characterized by dynamic and rapid developmental changes in the oral soft tissues and the emergence of teeth beginning around 6 months of age (107). Primary teeth begin forming around 7 weeks of intrauterine life and enamel formation is complete in the first year of life (24). Teeth begin emerging into the oral cavity once three-quarters of their roots are complete, and most primary teeth complete their root development by 3 years of age (24, 107).

The 20 primary teeth are at risk for dental caries as soon as they emerge into the oral cavity and are exposed to bacteria and fermentable carbohydrates (107). Risk factors leading to the demineralization of teeth and carious lesion progression include frequent consumption of dietary sugars, inadequate fluoride, poor oral hygiene, and salivary dysfunction (114). Protective factors leading to remineralization of teeth and carious lesion arrest or regression include healthy diet, brushing with fluoride toothpaste twice daily, professional topical fluoride, preventive and therapeutic sealants, and normal salivary function (114). Children with ECC have significantly lower oral health–related quality of life (QOL) than do children without ECC or children who received treatment for ECC, as assessed both by children and by their parents/guardians (46). Early tooth loss caused by advanced dental caries can result in failure to thrive and nutritional deficiencies in young children (107). Malnutrition and poor weight gain can have long-lasting developmental effects (29).

Once complete, the primary dentition is stable until the lower central incisors (sharp-edged teeth at the front of the mouth) become loose (mobile) at 5–6 years of age (107). This process is followed by exfoliation (shedding of primary teeth and their replacement by permanent teeth), with significant variation in timing by race/ethnicity, gender, and body mass index, where blacks, girls, and overweight/obesity are associated with earlier first permanent molar emergence (108).

Mixed dentition refers to the presence of both primary and permanent teeth in the oral cavity (107). The enamel on all permanent teeth except for third molars is complete by 8 years of age (24). By 12 years of age, most children have all their permanent teeth present or actively erupting in their mouths, except for third molars (107).

Dental caries is the most prevalent, and yet a largely preventable, chronic condition that disproportionately affects socioeconomically disadvantaged children, resulting in considerable QOL burdens, chronic tooth pain, and more than 51 million hours of classroom time lost annually (49, 53, 114). Untoward effects on chewing, swallowing, eating, and sleeping are found with severe caries, thereby posing problems with nutrition, development, and health (53). The provision of preventive oral health care services, early detection, and appropriate management of dental caries, including with nonsurgical treatment, are critical to improving the health of infants and children (41, 114, 132; see the sidebar titled Silver Diamine Fluoride and Caries Arrest and Prevention).

Second only to dental caries in prevalence among oral conditions (113), traumatic dental injuries (TDIs) occur with great frequency in preschool and school-aged children, comprising 5% of injuries for which treatment is sought (38, 79, 112). In the primary dentition, one-third of all children sustain a TDI, while in the permanent dentition, one-fourth of all children sustain a TDI (55, 113). Dental avulsion (complete displacement of a tooth from its socket in alveolar

SILVER DIAMINE FLUORIDE AND CARIES ARREST AND PREVENTION

Silver diamine fluoride (SDF) is a colorless alkaline liquid that incorporates the antibacterial effects of silver and the remineralizing action of fluoride to effectively arrest most carious lesions treated and reduce the cariogenic bacterial load. The dark staining of the lesions and affected tooth structures upon carious arrest may be a deterrent for certain patients/caregivers for aesthetic reasons. Clinical trials support the effectiveness of SDF for caries arrest in primary teeth, root caries prevention and arrest in permanent teeth, remineralization of incipient caries, and treatment of hypersensitive dentin. Its application is simple and inexpensive and requires minimal time and personnel. These advantages are particularly beneficial in low-resource community settings (preschools, nursing homes) and high-risk populations (young children and older adults with special needs) to overcome barriers related to insurance/cost, transportation, facilities access, and dental fear.

bone due to trauma) is an especially serious TDI, and the prognosis depends heavily on the actions taken at the site of injury and the oral health care that is immediately available and provided (10). Young athletes have been found to suffer from TDIs more often than professional athletes, and falls and collisions may mask intentional TDIs, such as physical abuse, assaults, and torture (55). Oral factors (protrusion of the teeth), socioeconomic conditions (material deprivation), and human behavior (risk taking, bullying, emotional stress, overweight/obesity, and attention-deficit hyperactivity disorder) increase the risk for TDIs (55).

5.2.2. Targeted interventions to reduce disparities in access to oral health care during infancy and childhood. The ACA requires most insurers to cover a package of health care services known as essential health benefits, with pediatric dental care explicitly identified as a covered service (43, 71, 138). The benefit for children and adolescents under the Medicaid program is known as Early and Periodic Screening, Diagnostic and Treatment services (EPSDT), which provides a comprehensive array of prevention, diagnostic, and treatment services, including oral health and dental services, for low-income infants, children, and adolescents under age 21, as specified in §1905(r) of the Social Security Act (109). These boosts in US federal policy have resulted in substantive improvements in dental coverage for children, even as socioeconomic and racial/ethnic disparities in dental visits and oral health indicators remain (43, 71).

For instance, despite the recommendation of pediatric health care organizations that children attend their first dental visit by age one year (2, 3, 20), nearly 10% of children already have dental caries by this developmental milestone, while only 2% have visited a dentist (1, 49). In contrast, the vast majority of children age one year (87%) have visited a physician (1).

Into the Mouths of Babes is a statewide program in North Carolina where pediatricians, family physicians, and providers in community health clinics are reimbursed by Medicaid to provide preventive dental services for children (risk assessment, screening, referral, fluoride varnish application) and caregivers (counseling) (20, 118). An ecological study using panel data from 920,505 kindergarten students documented reduced dental caries among targeted vulnerable children, which helped reduce oral health disparities among preschool-aged children in North Carolina (4).

Since 2014, the US Preventive Services Task Force has recommended that primary care clinicians apply fluoride varnish to the teeth of all children aged 5 years and younger to improve their oral health and reduce oral health care disparities (92). A US national evaluation of the impact of Medicaid reimbursement policies on fluoride varnish applications found that publicly insured children in states with fluoride varnish policies implemented for four or more years had significantly greater odds of having very good or excellent teeth compared with publicly insured children in states without fluoride varnish policies (72).

While many school-based health centers offer basic dental screening, there is a need for comprehensive oral health care, particularly for children in low-resource communities (49, 131). For instance, schools have partnered with an FQHC network, Family Health Centers at New York University (NYU) Langone, in Brooklyn, New York, to create dental homes on site using a business plan to deliver patient-centered and cost-effective oral health care (85). FQHCs have also been the prime sponsor of demonstration projects that integrate pediatric oral health and primary care services using a variety of collaborative models that, if sufficiently scaled up, hold promise for improving the oral and general health of disadvantaged children (35, 40, 53, 121).

5.3. Adolescence

5.3.1. Oral health conditions during adolescence. During puberty (preadolescence), which lasts from two to four years with an onset that varies by gender, race/ethnicity, and overweight/

obesity, growth and maturation of the body and maturation of the brain accelerate, with accompanying emotional, cognitive, and behavioral opportunities and challenges (107, 150). These physiological changes have a major impact on all areas and functions of the body, including the oral ecosystem (150). For instance, pubescent girls (typically aged 10–14 years) and pubescent boys (typically aged 12–16 years) may experience gingivitis due to enhanced inflammatory responses to plaque, even if their actual plaque levels have not increased (150).

By 13 years of age, most primary teeth have exfoliated and all permanent teeth, except for third molars, have emerged (107). While the timing varies, third molars typically emerge between 17 and 21 years of age (24). The roots of most permanent teeth, except third molars, are completely developed by 16 years of age (107). Poverty status, rather than race/ethnicity or gender, appears to be the main factor that influences the documented disparity in the experience of caries in permanent teeth among adolescents (42). Nevertheless, race/ethnicity along with poverty status contribute to the continued presence of oral health disparities among youth and young children in the United States (42).

While most states allow adolescents aged 12 years and older to consent to services for contraception, prenatal care, or sexually transmitted infections, these same adolescents are required to obtain parental consent for even preventive oral health care (22). This inconsistency serves to underscore the difficulties faced in providing age-appropriate oral health care services to adolescents, who are confronted with critical life choices before they are developmentally and emotionally mature. Severe consequences to their general and oral health and well-being may result from sexual activity, use of tobacco and alcohol, consumption of cariogenic foods and sugar-sweetened beverages, eating disorders, and oral piercings (107). Nurturing a sense of self-assurance in adolescents; providing them with the knowledge and engendering their self-confidence to deal with consequential life choices; reassuring them about being attractive, loved, and strong; and reinforcing their decisions to use evidence-based preventive measures (HPV vaccination, oral hygiene behaviors) will all guide them in developing the social competence and sense of responsibility to place them on a life course trajectory of enhanced health and well-being (107, 126, 150).

5.3.2. Targeted interventions to reduce disparities in access to oral health care during adolescence. Although the oral health status of young children has improved in the past decade, few changes have occurred for many older children and adolescents (42), even as comprehensive dental coverage is mandatory for both low-income children and adolescents enrolled in Medicaid (109). While parental/guardian consent is a valuable tool toward ensuring appropriate health care for adolescents, it can also be a barrier to timely access to basic preventive oral health services (22). In school-based oral health programs and FQHCs, where many socioeconomically disadvantaged adolescents receive care, services are provided at no cost to them or their parents/guardians regardless of insurance coverage or citizenship status, but the logistics of obtaining opt-in consent from every parent/guardian preclude upwards of 70% of eligible adolescents from receiving services (22, 49, 85). In states where opt-in consent is prescribed by custom but not by law, an opt-out process could be established without changing any laws and have an immediate positive impact on the consent rates that determine access to basic preventive oral health care for adolescents (22). Future research ought to be conducted to determine whether it is feasible to allow adolescents themselves to consent to preventive oral health care such as dental sealants and fluoride treatment, and at what age they are cognitively equipped for this type of health care decision making (22).

Most adolescents are not especially future oriented and thus do not regard themselves as vulnerable to health problems that will not result in symptoms until perhaps decades in the future, including oral and oropharyngeal cancers related to tobacco and alcohol use and sexual

PREVENTION OF HUMAN PAPILLOMAVIRUS–RELATED OROPHARYNGEAL CANCER

In 2014, the World Health Organization recommended that efficacy against incidence and persistent HPV infection can be a surrogate for disease risk. A number of studies have provided evidence that HPV vaccination decreases the rate of HPV-related infections and is likely to reduce the incidence of oropharyngeal cancer. Oral HPV infection is the primary risk factor for HPV-related oropharyngeal cancer, and more than 90% of oral HPV infections are sexually acquired.

In the United States, only two-thirds (66%) of adolescents have initiated the HPV vaccine series (55% in rural areas), and less than half (49%) have completed the series. On May 6, 2019, Oregon Governor Kate Brown signed a bill into law allowing dentists to offer any vaccine to a patient, including the HPV vaccine. Implementation and referral guidelines in Oregon and other states are undergoing review by boards, dental providers, and researchers.

activity [149; see sidebar titled Prevention of Human Papillomavirus (HPV) Related Oropharyngeal Cancer]. Motivational interviewing (MI) is a person-centered counseling strategy that elicits the intrinsic motivation of patients, enhances their commitment, and explores their own solutions toward change (149). A growing body of research and decades of experience indicate that MI is an effective method for facilitating behavior change in adolescents, including for unfavorable oral health behaviors such as infrequent toothbrushing and frequent snacking (149). The American Academy of Pediatrics advises providers that once MI techniques are mastered, they can be used effectively in brief sessions. Furthermore, MI can reduce stress and frustration on the part of providers by involving patients in the problem-solving process, thus increasing the likelihood that adolescents will find solutions that work for them.

5.4. Adulthood and Older Age

5.4.1. Oral health conditions during adulthood and older age. Over the past decade, an increasing number of US children, especially disadvantaged children, have been visiting the dentist, and the gap in rates of oral health care between disadvantaged and advantaged children has been narrowing (137–139). In contrast, oral health care utilization for US adults has declined during this time period, especially among the poor and uninsured, and in many states the gap in rates of oral health care between disadvantaged and advantaged adults has been widening (137–139). Compared with children and older adults, adults aged 19–64 years are much more likely to face financial barriers to all types of health care, and more people regardless of income, age, or source of dental benefits report financial barriers to dental care than to medical care, prescription drugs, eyeglasses, and mental health care (138). Since Medicare covers only narrowly defined medically necessary dental procedures and many state Medicaid programs do not cover dental services for adults, adults pay an increasing portion of their dental expenditures out of pocket as they age (59).

In a recent national survey conducted with respondents aged 18 years and older, of those who had not visited a dentist in the last 12 months, cost is the primary reason regardless of income, age, or source of dental benefits (5). Among adults with Medicaid, cost remains the primary reason (50%), but trouble finding a dentist is second (41%) and more frequently cited than for adults with private insurance (14%), other insurance (30%), or no insurance (13%). Yet nearby provider supply is not related to the identification of a usual source of primary or dental care for adults newly enrolled in Medicaid (27). Interventions to reduce oral health care disparities clearly need

to do more, at the policy and community level, to enhance linkages between health care systems and the communities they serve (115).

As adults age, reduced levels of salivary mucins may lead to lower lubrication and comfort, while reduction in salivary histatins, known to possess antifungal activity, may result in *Candida* outgrowth (150). Gingival recession also increases with age, exposing the root surfaces to the oral environment and thus to the risk of developing root caries lesions (148). Among older adults, tooth loss is associated with poor nutrition, leading to both weight loss and obesity (59). Socioeconomic disadvantage in middle age has a strong influence on tooth loss in older age, and poor self-rated oral health in older age is influenced by socioeconomic disadvantage across the life course (116). On the other hand, long-term routine dental attendance improves oral health–related QOL (12).

Large racial/ethnic disparities in tooth loss and dental visits exist across the United States and are exacerbated in rural areas owing to an underresourced rural and remote health care infrastructure (23). Ultimately, the oral health of older adults represents an accumulation of life course experiences, and greater public health attention should be focused on oral health as an important indicator of healthful aging (23, 59, 96).

5.4.2. Targeted interventions to reduce disparities in access to oral health care during adulthood and older age. In response to fiscal challenges, many states have reduced or eliminated Medicaid dental coverage over the past decade, with a concurrent 10% decline in oral health care utilization among low-income adults (5, 6). Moreover, Medicaid enrollees often have difficulty finding Medicaid-contracted dental providers because only 20% of dentists nationwide accept Medicaid, citing burdensome administrative requirements, missed appointments, lengthy payment wait times, and low reimbursement rates as barriers to participation (5, 6).

To reverse these sobering trends and consequences, there is a critical need for interventions at multiple levels to improve access to oral health care for adults, including ensuring a safety net that covers basic and restorative services to eliminate pain and infection at the policy and community level (59, 115). At the organization and provider level, interventions are needed to (*a*) demonstrate whether and how team-based care using, e.g., community health workers (100) and nursing home staff (145), can be used to improve access to and coordination of primary and oral health care for underserved population groups; (*b*) determine how to optimize the use of data sources and health information technology to improve the communication skills and cultural competence of providers and reduce the impact of biases against underserved population groups; and (*c*) increase the focus of health care organization leaders on oral health equity as an essential element in quality improvement (115).

At the family, friends, and social support level, efforts are needed to better address cultural differences in family decision making and that make use of social network dynamics in intervention approaches (115). Family-based and intergenerational interventions have proven effective in populations with severe oral health care needs, including older racial/ethnic minorities, immigrants, and homeless people (39, 70, 102). At the individual level, more interventions are needed that include less well-studied populations such as Chinese Americans and other Asian subgroups, Indigenous people, rural residents, refugees, and immigrants (23, 37, 100, 115, 127).

6. CONCLUSIONS: CREATING AN INTEGRATED AND EQUITABLE SYSTEM OF CARE

This review has focused on US disparities in access to oral health care across the life course. The net result is a greater likelihood of poor oral health at every age for people who are low-income, uninsured, and/or members of racial/ethnic minority, immigrant, or rural populations than for

populations with better access to quality oral health care. While progress has been achieved in narrowing the oral health care gap for disadvantaged children over the past decade, the gap for every other age group has either stayed the same or widened. Both universal and targeted interventions at multiple levels of influence are needed to eliminate disparities in access to oral health care and end the disgrace of poor oral health as the national symbol of social inequality.

In the future, oral health professionals will care for more racially/ethnically diverse patients, older patients with complex medical and dental needs, and younger patients who will require fewer restorative and prosthodontic treatments than did previous generations (144). To address disparities in access to oral health care, the Institute of Medicine and the National Research Council recommend that the HRSA further expand the capacity of FQHCs to deliver essential oral health services (66). While FQHCs are uniquely positioned to provide integrated, patient-centered care, they experience challenges related to the oral health literacy of patients and to the building of sufficient capacity to meet the high demand for oral health care services (74).

Thus, there needs to be continued development of integrative technology and health care models that are designed for the communities they serve, recognizing the needs of families and individuals with limited resources. Federal agencies, notably HRSA, the National Institute of Dental and Craniofacial Research (NIDCR), and the Agency for Healthcare Research and Quality (AHRQ), along with philanthropic organizations deserve credit and increased support for funding programmatic, research, and health policy committed to oral health care equity. By leveraging the commitment of public health, medical, and dental leaders and practitioners to integrate and refocus training, redesign and expand coverage, and translate the evidence base of science (89), no one at any age will need to endure pain and suffering because of a lack of access to oral health care.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review. The content is solely the responsibility of the authors and does not necessarily represent the official views of NIH or HRSA.

ACKNOWLEDGMENTS

Partial support for M.E.N. and/or her research was provided by grants R01DE023072 and U56DE027447 from the National Institute of Dental and Craniofacial Research (NIDCR) of the US National Institute of Health (NIH), grant T93HP30391 from the Health Resources and Services Administration (HRSA), and grant P30CA016087 from the New York University (NYU) Laura and Isaac Perlmutter Cancer Center Support Grant's Developmental Project Program funded by the National Cancer Institute (NCI) of the NIH.

LITERATURE CITED

1. AAP (Am. Acad. Pediatr.). 2010. *Profile of pediatric visits*. Rep., AAA, Elk Grove Village, IL. **https://www.aap.org/en-us/professional-resources/practice-transformation/managing-practice/Pages/Profile-of-Pediatric-Office-Visits.aspx**
2. AAP (Am. Acad. Pediatr.), Section on Oral Health. 2014. Maintaining and improving the oral health of young children. *Pediatrics* 134(6):1224–29
3. AAPD (Am. Acad. Pediatr. Dent.). 2013. Guideline on periodicity of examination, preventive dental services, anticipatory guidance/counseling, and oral treatment for infants, children, and adolescents. *Pediatr. Dent.* 37(6):123–30

4. Achembong LN, Kranz AM, Rozier RG. 2014. Office-based preventive dental program and statewide trends in dental caries. *Pediatrics* 133(4):e827–34
5. ADA (Am. Dent. Assoc.), Health Policy Inst. 2016. *Oral health and well-being in the United States*. Fact Sheet, ADA, Chicago. **https://www.ada.org/en/science-research/health-policy-institute/oral-health-and-well-being**
6. ADA (Am. Dent. Assoc.), Health Policy Inst. 2019. *Dental practice*. Fact Sheet, ADA, Chicago. **https://www.ada.org/en/science-research/health-policy-institute/data-center/dental-practice**
7. Adams SH, Gregorich SE, Rising SS, Hutchison M, Chung LH. 2017. Integrating a nurse-midwife-led oral health intervention into CenteringPregnancy prenatal care: results of a pilot study. *J. Midwifery Women's Health* 62(4):463–69
8. Allukian M Jr., Horowitz AM, Wong CA. 2013. Oral health. In *Social Injustice and Public Health*, ed. BS Levy, VW Sidel, pp. 359–78. New York: Oxford Univ. Press. 2nd ed.
9. Andås CA, Hakeberg M. 2014. Who chooses prepaid dental care? A baseline report of a prospective observational study. *BMC Oral Health* 14:146
10. Andersson L, Andreasen JO, Day P, Heithersay G, Trope M, et al. 2017. Guidelines for the management of traumatic dental injuries: 2. Avulsion of permanent teeth. *Pediatr. Dent.* 39(6):412–19
11. Arevalo O, Tomar SL. 2019. Perpetual inequities in access to dental care: government or professional responsibility? See Treadwell & Evans 2019, pp. 25–42
12. Åstrøm AN, Ekback G, Ordell S, Gulcan F. 2018. Changes in oral health-related quality of life (OHRQoL) related to long-term utilization of dental care among older people. *Acta Odontol. Scand.* 76(8):559–66
13. Atchison KA, Weintraub JA, Rozier RG. 2018. Bridging the dental-medical divide: case studies integrating oral health care and primary health care. *J. Am. Dent. Assoc.* 149(10):850–58
14. Ben-Shlomo Y, Kuh D. 2002. A life course approach to chronic disease epidemiology: conceptual models, empirical challenges, and interdisciplinary perspectives. *Int. J. Epidemiol.* 31(2):285–93
15. Benzian H, Williams D, eds. 2015. *The Challenge of Oral Disease: A Call for Global Action*. Brighton, UK: Myriad Ed.
16. Braveman P. 2006. Health disparities and health equity: concepts and measurement. *Annu. Rev. Public Health* 27:167–94
17. Braveman P, Gruskin S. 2003. Defining equity in health. *J. Epidemiol. Community Health* 57:254–58
18. Broadbent JM, Thomson WM, Poulton R. 2008. Trajectory patterns of dental caries experience in the permanent dentition to the fourth decade of life. *J. Dent. Res.* 87(1):69–72
19. Broadbent JM, Zeng J, Foster Page LA, Baker SR, Ramrakha S, Thomson WM. 2016. Oral health-related beliefs, behaviors, and outcomes through the life course. *J. Dent. Res.* 95(7):808–13
20. Burgette JM, Preisser JS, Rozier RG. 2018. Access to preventive services after the integration of oral health care into early childhood education and medical care. *J. Am. Dent. Assoc.* 149(12):1024–31.e2
21. Burt BA, Eklund SA, Morgan KJ, Larkin FE, Guire KE, et al. 1988. The effects of sugars intake and frequency of ingestion on dental caries increment in a three-year longitudinal study. *J. Dent. Res.* 67(11):1422–29
22. Calderon SJ, Mallory C, Malin M. 2017. Parental consent and access to oral health care for adolescents. *Policy Polit. Nurs. Pract.* 18(4):186–94
23. Caldwell JT, Lee H, Cagney KA. 2017. The role of primary care for the oral health of rural and urban older adults. *J. Rural Health* 33(4):409–18
24. Casamassimo P, Fields HW Jr., McTigue DJ, Nowak AJ. 2012. *Pediatric Dentistry: Infancy through Adolescence*. St Louis, MO: Elsevier Saunders. 5th ed.
25. CDC (Cent. Dis. Control Prev.). 1999. Achievements in public health 1900–1999: fluoridation of drinking water to prevent dental caries. *MMWR* 48(41):933–40
26. Chaffee BW, Gansky SA, Weintraub JA, Featherstone JD, Ramos-Gomez FJ. 2014. Maternal oral bacterial levels predict early childhood caries development. *J. Dent. Res.* 93(3):238–44
27. Chaiyachati KH, Hom JK, Wong C, Nasseh K, Chen X, et al. 2019. Access to primary and dental care among adults newly enrolled in Medicaid. *Am. J. Manag. Care* 25(3):135–39

28. Clarke AR, Goddu AP, Nocon RS, Stock NW, Chyr LC, et al. 2013. Thirty years of disparities intervention research: What are we doing to close racial and ethnic gaps in health care? *Med. Care* 51(11):1020–26
29. Clarke M, Locker D, Berall G, Pencharz P, Kenny DJ, Judd P. 2006. Malnourishment in a population of young children with severe early childhood caries. *Pediatr. Dent.* 28(3):254–59
30. Cobb CM, Kelly PJ, Williams KB, Babbar S, Angolkar M, Derman RJ. 2017. The oral microbiome and adverse pregnancy outcomes. *Int. J. Women's Health* 9:551–59
31. Collares K, Opdam NJ, Peres KG, Peres MA, Horta BL, et al. 2018. Higher experience of caries and lower income trajectory influence the quality of restorations: a multilevel analysis in a birth cohort. *J. Dent.* 68:79–84
32. Como DH, Stein Duker LI, Polido JC, Cermak SA. 2019. The persistence of oral health disparities for African American children: a scoping review. *Int. J. Environ. Res. Public Health* 16(5):E710
33. Connor KM, Davidson JRT. 2003. Development of a new resilience scale: the Connor-Davidson resilience scale (CD-RISC). *Depress. Anxiety* 18(2):76–82
34. Correa MB, Peres MA, Peres KG, Horta BL, Barros AJ, Demarco FF. 2013. Do socioeconomic determinants affect the quality of posterior dental restorations? A multilevel approach. *J. Dent.* 41(11):960–67
35. Crall JJ, Illum J, Martinez A, Pourat N. 2016. *An innovative project breaks down barriers to oral health care for vulnerable young children in Los Angeles County*. Policy Brief PB2016–5, Univ. Calif. Los Angel., Cent. Health Policy Res., Los Angel. **http://healthpolicy.ucla.edu/publications/Documents/PDF/2016/childdentalbrief-jun2016.pdf**
36. Davis AM, Vinci LM, Okwuosa TM, Chase AR, Huang ES. 2007. Cardiovascular health disparities: a systematic review of health care interventions. *Med. Care Res. Rev.* 64(5 Suppl.):29S–100
37. Demby N, Northridge ME. 2018. Delivering equitable care to underserved communities. *Am. J. Public Health* 108(11):1446–47
38. Diangelis AJ, Andreasen JO, Ebeleseder KA, Kenny DJ, Trope M, et al. 2017. Guidelines for the management of traumatic dental injuries: 1. Fractures and luxations of permanent teeth. *Pediatr. Dent.* 39(6):401–11
39. Dolce MC, Parker JL, Bhalla P, Anderson C. 2018. A cooperative education model for promoting oral health and primary care integration within a health care for the homeless program. *J. Health Care Poor Underserved* 29(2):591–600
40. Dooley D, Moultrie NM, Heckman B, Gansky SA, Potter MB, Walsh MM. 2016. Oral health prevention and toddler well-child care: routine integration in a safety net system. *Pediatrics* 137(1):e20143532
41. Duangthip D, Jiang M, Chu CH, Lo EC. 2015. Non-surgical treatment of dentin caries in preschool children—a systematic review. *BMC Oral Health* 15:44
42. Dye BA, Mitnik GL, Iafolla TJ, Vargas CM. 2017. Trends in dental caries in children and adolescents according to poverty status in the United States from 1999 through 2004 and from 2011 through 2014. *J. Am. Dent. Assoc.* 148(8):550–65.e7
43. Edelstein BL. 2018. Pediatric oral health policy: its genesis, domains, and impacts. *Pediatr. Clin. North Am.* 65(5):1085–96
44. Estrada I, Kunzel C, Schrimshaw EW, Greenblatt AP, Metcalf SS, Northridge ME. 2018. "Seniors only want respect": designing an oral health program for older adults. *Spec. Care Dentist.* 38(1):3–12
45. Featherstone JD. 2004. The continuum of dental caries—evidence for a dynamic disease process. *J. Dent. Res.* 83:C39–42
46. Filstrup FL, Briskie D, da Fonseca M, Lawrence L, Wandera A, Inglehart MR. 2003. Early childhood caries and quality of life: child and parent perspectives. *Pediatr. Dent.* 25(5):431–40
47. Finlayson TL, Gupta A, Ramos-Gomez FJ. 2017. Prenatal maternal factors, intergenerational transmission of disease, and child oral health outcomes. *Dent. Clin. North. Am.* 61(3):483–518
48. Fisher-Owens SA, Gansky SA, Platt LJ, Weintraub JA, Soobader MJ, et al. 2007. Influences on children's oral health: a conceptual model. *Pediatrics* 120(3):e510–20
49. Fisher-Owens SA, Mertz E. 2018. Preventing oral disease: alternative providers and places to address this commonplace condition. *Pediatr. Clin. North Am.* 65(5):1063–72

50. Formicola AJ, Ro M, Marshall S, Derksen D, Powell W, et al. 2004. Strengthening the oral health safety net: delivery models that improve access to oral health care for uninsured and underserved populations. *Am. J. Public Health* 94(5):702–4
51. Fox C, Eichelberger K. 2015. Maternal microbiome and pregnancy outcomes. *Fertil. Steril.* 104(6):1358–63
52. Gallo LC, de los Monteros KE, Shivpuri S. 2009. Socioeconomic status and health: What is the role of reserve capacity? *Curr. Dir. Psychol. Sci.* 18(5):269–74
53. Gauger TL, Prosser LA, Fontana M, Polverini PJ. 2018. Integrative and collaborative care models between pediatric oral health and primary care providers: a scoping review of literature. *J. Public Health Dent.* 78(3):246–56
54. Gies WJ. 1926. *Dental Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching*. New York: Carnegie Found. Adv. Teach.
55. Glendor U. 2009. Aetiology and risk factors related to traumatic dental injuries—a review of the literature. *Dent. Traumatol.* 25(1):19–31
56. Glick SB, Clarke AR, Blanchard A, Whitaker AK. 2012. Cervical cancer screening, diagnosis and treatment interventions for racial and ethnic minorities: a systematic review. *J. Gen. Intern. Med.* 27(8):1016–32
57. Gorin SS, Badr H, Krebs P, Prabhu Das I. 2012. Multilevel interventions and racial/ethnic health disparities. *J. Natl. Cancer Inst. Monogr.* 2012(44):100–11
58. Greenblatt AP, Estrada I, Schrimshaw EW, Metcalf SS, Kunzel C, Northridge ME. 2017. Acceptability of chairside screening for racial/ethnic minority older adults: a qualitative study. *JDR Clin. Trans. Res.* 2(4):343–52
59. Griffin SO, Jones JA, Brunson D, Griffin PM, Bailey WD. 2012. Burden of oral disease among older adults and implications for public health priorities. *Am. J. Public Health* 102(3):411–18
60. Halfon N, Larson K, Lu M, Tullis E, Russ S. 2014. Lifecourse health development: past, present and future. *Matern. Child Health J.* 18(2):344–65
61. Harnett E, Haber J, Krainovich-Miller B, Bella A, Vasilyeva A, Lange Kessler J. 2016. Oral health in pregnancy. *J. Obstet. Gynecol. Neonatal Nurs.* 45(4):565–73
62. Hartsock LG, Hall MB, Connor AM. 2006. Informing the policy agenda: the community voices experience on dental health for children in North Carolina's rural communities. *J. Health Care Poor Underserved* 17(1 Suppl.):111–23
63. Horowitz HS. 1996. The effectiveness of community water fluoridation in the United States. *J. Public Health Dent.* 56(5 Spec No):253–58
64. Iida H. 2017. Oral health interventions during pregnancy. *Dent. Clin. North Am.* 61(3):467–81
65. IOM (Inst. Med.). 2011. *Advancing Oral Health in America*. Washington, DC: Natl. Acad. Press
66. IOM (Inst. Med.), NRC (Nat. Res. Counc.). 2011. *Improving Access to Oral Health Care for Vulnerable and Underserved Populations*. Washington, DC: Natl. Acad. Press
67. Jacobsen PE, Haubek D, Henriksen TB, Østergaard JR, Poulsen S. 2014. Developmental enamel defects in children born preterm: a systematic review. *Eur. J. Oral. Sci.* 122(1):7–14
68. Julihn A, Ekbom A, Modéer T. 2009. Maternal overweight and smoking: prenatal risk factors for caries development in offspring during the teenage period. *Eur. J. Epidemiol.* 24(12):753–62
69. Kilian M, Chapple IL, Hannig M, Marsh PD, Meuric V, et al. 2016. The oral microbiome—an update for oral healthcare professionals. *Br. Dent. J.* 221(10):657–66
70. King TB, Gibson G. 2003. Oral health needs and access to dental care of homeless adults in the United States: a review. *Spec. Care Dentist.* 23(4):143–47
71. Kranz AM, Dick AW. 2019. Changes in pediatric dental coverage and visits following the implementation of the Affordable Care Act. *Health Serv. Res.* 54(2):437–45
72. Kranz AM, Duffy E, Dick AW, Sorbero M, Rozier RG, Stein BD. 2019. Impact of Medicaid policy on the oral health of publicly insured children. *Matern. Child Health J.* 23(1):100–8
73. Laine MA. 2002. Effect of pregnancy on periodontal and dental health. *Acta Odontol. Scand.* 60(5):257–64
74. Langelier M, Moore J, Baker BK, Mertz E. 2015. *Case studies of 8 Federally Qualified Health Centers: strategies to integrate oral health with primary care*. Rep., Cent. Health Workforce Stud., Sch. Public Health,

Univ. Albany, State Univ. N. Y., Rensselaer, NY. **http://www.oralhealthworkforce.org/wp-content/uploads/2015/11/FQHC-Case-Studies-2015.pdf**
75. Leong PM, Gussy MG, Barrow SY, de Silva-Sanigorski A, Waters E. 2013. A systematic review of risk factors during first year of life for early childhood caries. *Int. J. Paediatr. Dent.* 23(4):235–50
76. Locker D. 2009. Self-esteem and socioeconomic disparities in self-perceived oral health. *J. Public Health Dent.* 69(1):1–8
77. Lukes SM, Simon B. 2006. Dental services for migrant and seasonal farmworkers in US community/migrant health centers. *J. Rural Health* 22(3):269–72
78. Luo H, Bell RA, Wright W, Wu Q, Wu B. 2018. Trends in annual dental visits among US dentate adults with and without self-reported diabetes and prediabetes, 2004–2014. *J. Am. Dent. Assoc.* 149(6):460–69
79. Malmgren B, Andreasen JO, Flores MT, Robertson A, DiAngelis AJ, et al. 2017. Guidelines for the management of traumatic dental injuries: 3. Injuries in the primary dentition. *Pediatr. Dent.* 39(6):420–28
80. Manski RJ, Hoffmann D, Rowthorn V. 2015. Increasing access to dental and medical care by allowing greater flexibility in scope of practice. *Am. J. Public Health* 105(9):1755–62
81. Manski RJ, Rohde F. 2017. *Dental services: use, expenses, source of payment, coverage and procedure type, 1996–2015*. Res. Find. 38, Agency Healthc. Res. Quality, Rockville, MD. **https://meps.ahrq.gov/mepsweb/data_files/publications/rf38/rf38.pdf**
82. Marsh PD. 2003. Are dental diseases examples of ecological catastrophes? *Microbiology* 149(Pt. 2):279–94
83. Marsh PD, Head DA, Devine DA. 2015. Ecological approaches to oral biofilms: control without killing. *Caries Res.* 49(Suppl. 1):46–54
84. Martins AB, Dos Santos CM, Hilgert JB, de Marchi RJ, Hugo FN, Pereira Padilha DM. 2011. Resilience and self-perceived oral health: a hierarchical approach. *J. Am. Ger. Soc.* 59(4):725–31
85. Mason MK, Gargano L, Kumar A, Northridge ME. 2019. Implementing a patient-centered and cost-effective school-based oral health program. *J. School Health.* 89(12):1024–27
86. McCauley HB. 1998. Professional dentistry's road to autonomy. *J. Hist. Dent.* 46(2):59–64
87. McCauley HB. 2003. The first dental college: emergence of dentistry as an autonomous profession. *J. Hist. Dent.* 51(1):41–45
88. McLeroy KR, Bibeau D, Steckler A, Glanz K. 1988. An ecological perspective on health promotion programs. *Health Educ. Q.* 15(4):351–77
89. Mertz EA. 2016. The dental-medical divide. *Health Aff.* 35(12):2168–75
90. Mertz EA, Wides CD, Kottek AM, Calvo JM, Gates PE. 2016. Underrepresented minority dentists: quantifying their numbers and characterizing the communities they serve. *Health Aff.* 35(12):2190–99
91. Milgrom P, Reisine S. 2000. Oral health in the United States: the post-fluoride generation. *Annu. Rev. Public Health* 21:403–36
92. Moyer VA. 2014. Prevention of dental caries in children from birth through age 5 years: US Preventive Services Task Force recommendation statement. *Pediatrics* 133(6):1102–11
93. Moynihan PJ, Kelly SA. 2014. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. *J. Dent. Res.* 93(1):8–18
94. Mueller M, Purnell TS, Mensah GA, Cooper LA. 2015. Reducing racial and ethnic disparities in hypertension prevention and control: What will it take to translate research into practice and policy? *Am. J. Hypertens.* 28(6):699–716
95. Nasseh K, Vujicic M, Glick M. 2017. The relationship between periodontal interventions and healthcare costs and utilization. Evidence from an integrated dental, medical, and pharmacy commercial claims database. *Health Econ.* 26(4):519–27
96. Northridge ME. 2018. Oral health equity for minority populations in the United States. In *Oxford Bibliographies in Public Health*. Oxford, UK: Oxford Univ. Press. **http://0-www.oxfordbibliographiesonline.com/view/document/obo-9780199756797/obo-9780199756797-0172.xml**
97. Northridge ME, Chakraborty B, Salehabadi SM, Metcalf SS, Kunzel C, et al. 2018. Does Medicaid coverage modify the relationship between glycemic status and teeth present in older adults? *J. Health Care Poor Underserved* 29(4):1509–28

98. Northridge ME, Estrada I, Schrimshaw EW, Greenblatt AP, Metcalf SS, Kunzel C. 2017. Racial/ethnic minority older adults' perspectives on proposed Medicaid reforms' effects on dental care access. *Am. J. Public Health* 107(S1):S65–70
99. Northridge ME, Lamster IB. 2004. A life course approach to preventing and treating oral disease. *Soz Praventivmed*. 49(5):299–300
100. Northridge ME, Metcalf SS, Yi S, Zhang Q, Gu X, Trinh-Shevrin C. 2018. A protocol for a feasibility and acceptability study of a participatory, multi-level, dynamic intervention in urban outreach centers to improve the oral health of low-income Chinese Americans. *Front. Public Health* 6:29
101. Northridge ME, Schenkel AB, Birenz S, Estrada I, Metcalf SS, Wolff MS. 2017. "You get beautiful teeth down there": racial/ethnic minority older adults' perspectives on dental school clinics. *J. Dent. Educ.* 81(11):1273–82
102. Northridge ME, Schrimshaw EW, Estrada I, Greenblatt AP, Metcalf SS, Kunzel C. 2017. Intergenerational and social interventions to improve children's oral health. *Dent. Clin. North Am.* 61(3):533–48
103. Northridge ME, Shedlin M, Schrimshaw EW, Estrada I, De La Cruz L, et al. 2017. Recruitment of racial/ethnic minority older adults through community sites for focus group discussions. *BMC Public Health* 17(1):563
104. Northridge ME, Ue F, Borrell LN, Bodnar S, De La Cruz L, et al. 2012. Tooth loss and dental caries in community-dwelling older adults in northern Manhattan. *Gerodontology* 29(2):e464–73
105. ODPHP (Off. Dis. Prev. Health Promot.). 2019. 2020 Leading health indicators. Oral health. *Healthy-People.gov.* **https://www.healthypeople.gov/2020/leading-health-indicators/2020-lhi-topics/Oral-Health**
106. Oral Health Care During Pregnancy Expert Workgroup. 2012. *Oral health care during pregnancy: a national consensus statement*. Rep., Natl. Matern. Child Oral Health Resour. Cent., Washington, DC. **https://www.mchoralhealth.org/PDFs/OralHealthPregnancyConsensus.pdf**
107. Pahel BT, Rowan-Legg A, Quinonez RB. 2018. A developmental approach to pediatric oral health. *Pediatr. Clin. North Am.* 65(5):885–907
108. Pahel BT, Vann WF Jr., Divaris K, Rozier RG. 2017. A contemporary examination of first and second permanent molar emergence. *J. Dent. Res.* 96(10):1115–21
109. Paradise J, Lyons B, Rowland D. 2015. *Medicaid at 50*. Rep., Henry J. Kaiser Family Found., Menlo Park, CA. **http://files.kff.org/attachment/report-medicaid-at-50**
110. Paskett E, Thompson B, Ammerman AS, Ortega AN, Marsteller J, Richardson D. 2016. Multilevel interventions to address health disparities show promise in improving population health. *Health Aff.* 35(8):1429–34
111. Patrick DL, Lee RS, Nucci M, Grembowski D, Jolles CZ, Milgrom P. 2006. Reducing oral health disparities: a focus on social and cultural determinants. *BMC Oral Health* 6(Suppl. 1):S4
112. Petersson EE, Andersson L, Sörensen S. 1997. Traumatic oral versus non-oral injuries. *Swed. Dent. J.* 21(1–2):55–68
113. Petti S, Glendor U, Andersson L. 2018. World traumatic dental injury prevalence and incidence, a meta-analysis—one billion living people have had traumatic dental injuries. *Dent. Traumatol.* 34(2):71–86
114. Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, et al. 2017. Dental caries. *Nat. Rev. Dis. Primers* 3:17030
115. Purnell TS, Calhoun EA, Golden SH, Halladay JR, Krok-Schoen JL, et al. 2016. Achieving health equity: closing the gaps in health care disparities, interventions, and research. *Health Aff.* 35(8):1410–15
116. Ramsay SE, Papachristou E, Watt RG, Lennon LT, Papacosta AO, et al. 2018. Socioeconomic disadvantage across the life-course and oral health in older age: findings from a longitudinal study of older British men. *J. Public Health* 40(4):e423–30
117. Reisine S, Litt M, Tinanoff N. 1994. A biopsychosocial model to predict caries in preschool children. *Pediatr. Dent.* 16(6):413–18
118. Rozier RG, Sutton BK, Bawden JW, Haupt K, Slade GD, King RS. 2003. Prevention of early childhood caries in North Carolina medical practices: implications for research and practice. *J. Dent. Educ.* 67(8):876–85

119. Salganicoff A, Ranji U, Sobel L. 2015. Medicaid at 50: marking a milestone for women's health. *Women's Health Issues* 25(3):198–201
120. Sallis JF, Owen N, Fisher EB. 2008. Ecological models of health behavior. In *Health Behavior and Health Education: Theory, Research, and Practice*, ed. K Glanz, BK Rimer, K Viswanath, pp. 465–82. San Francisco: Jossey-Bass. 4th ed.
121. Sengupta N, Nanavati S, Cericola M, Simon L. 2017. Oral health integration into a pediatric practice and coordination of referrals to a colocated dental home at a Federally Qualified Health Center. *Am. J. Public Health* 107(10):1627–29
122. Silk H, Douglass AB, Douglass JM, Silk L. 2008. Oral health during pregnancy. *Am. Fam. Physician* 77(8):1139–44
123. Sischo L, Broder HL. 2011. Oral health-related quality of life: what, why, how, and future implications. *J. Dent. Res.* 90(11):1264–70
124. Sparer M. 2011. US health care reform and the future of dentistry. *Am. J. Public Health* 101(10):1841–44
125. Sullivan Comm. 2004. *Missing persons: minorities in the health professions. A report of the Sullivan Commission on Diversity in the Healthcare Workforce*. Rep., Sullivan Comm., Durham, NC. **https://depts.washington.edu/ccph/pdf_files/SullivanReport.pdf**
126. Timbang MR, Sim MW, Bewley A, Farwell DG, Mantravadi A, Moore M. 2019. HPV-related oropharyngeal cancer: a review on burden of the disease and opportunities for prevention and early detection. *Hum. Vaccin. Immunother.* 15:1920–28
127. Tiwari T, Jamieson L, Broughton J, Lawrence HP, Batliner TS, et al. 2018. Reducing Indigenous oral health inequalities: a review from 5 nations. *J. Dent. Res.* 97(8):869–77
128. Tomar SL, Cohen LK. 2010. Attributes of an ideal oral health care system. *J. Public Health Dent.* 70(Suppl. 1):S6–14
129. Treadwell HM, Evans CA, eds. 2019. *Oral Health in America: Removing the Stain of Disparity*. Washington, DC: Am. Public Health Assoc.
130. Treadwell HM, Northridge ME. 2007. Oral health is the measure of a just society. *J. Health Care Poor Underserved* 18(1):12–20
131. Trudnak Fowler T, Matthews G, Black C, Crosby Kowal H, Vodicka P, Edgerton E. 2018. Evaluation of a comprehensive oral health services program in school-based health centers. *Matern. Child Health J.* 22(7):998–1007
132. US DHHS (Dep. Health Hum. Serv.). 2000. *Oral health in America: a report of the Surgeon General*. Rep., US DHHS, Rockville, MD. **https://www.nidcr.nih.gov/sites/default/files/2017-10/hck1ocv.%40www.surgeon.fullrpt.pdf**
133. US DHHS (Dep. Health Hum. Serv.). 2003. *A national call to action to promote oral health*. NIH Publ. 03–5303, US DHHS, Public Health Serv., Natl. Inst. Health, Natl. Inst. Dent. Craniofac. Res., Rockville, MD
134. US DHHS (Dep. Health Hum. Serv.). 2014. *Integration of oral health and primary care practice*. US DHHS, Health Res. Serv. Admin., Rockville, MD. **https://www.hrsa.gov/sites/default/files/hrsa/oralhealth/integrationoforalhealth.pdf**
135. Vander Schaaf EB, Quinonez RB, Cornett AC, Randolph GD, Boggess K, Flower KB. 2018. A pilot quality improvement collaborative to improve safety net dental access for pregnant women and young children. *Matern. Child Health J.* 22(2):255–63
136. Vinturache AE, Gyamfi-Bannerman C, Hwang J, Mysorekar IU, Jacobsson B, Preterm Birth Int. Collab. (PREBIC). 2016. Maternal microbiome—a pathway to preterm birth. *Semin. Fetal Neonatal Med.* 21(2):94–99
137. Vujicic M. 2014. A tale of two safety nets. *J. Am. Dent. Assoc.* 145(1):83–85
138. Vujicic M, Buchmueller T, Klein R. 2016. Dental care presents the highest level of financial barriers, compared to other types of health care services. *Health Aff.* 35(12):2176–82
139. Vujicic M, Nasseh K. 2014. A decade in dental care utilization among adults and children (2001–2010). *Health Serv. Res.* 49(2):460–80

140. Watt RG. 2007. From victim blaming to upstream action: tackling the social determinants of oral health inequalities. *Community Dent. Oral Epidemiol.* 35(1):1–11
141. Watt RG. 2012. Social determinants of oral health inequalities: implications for action. *Community Dent. Oral Epidemiol.* 40(Suppl. 2):44–48
142. Watt RG, Mathur MR, Aida J, Bönecker M, Venturelli R, Gansky SA. 2018. Oral health disparities in children: a canary in the coalmine? *Pediatr. Clin. North Am.* 65(5):965–79
143. Watt RG, Sheiham A. 2012. Integrating the common risk factor approach into a social determinants framework. *Community Dent. Oral Epidemiol.* 40(4):289–96
144. Weintraub JA. 2017. What should oral health professionals know in 2040: executive summary. *J. Dent. Educ.* 81(8):1024–32
145. Weintraub JA, Zimmerman S, Ward K, Wretman CJ, Sloane PD, et al. 2018. Improving nursing home residents' oral hygiene: results of a cluster randomized intervention trial. *J. Am. Med. Dir. Assoc.* 19(12):1086–91
146. Whitehead M. 1990. *The concepts and principles of equity in health*. EUR/ICP/RPD 414 7734r, World Health Organ., Reg. Off. Eur., Copenhagen
147. Whitehead M. 1992. The concepts and principles of equity in health. *Int. J. Health Serv.* 22:429–45
148. Wierichs RJ, Meyer-Lueckel H. 2015. Systematic review on noninvasive treatment of root caries lesions. *J. Dent. Res.* 94(2):261–71
149. Wu L, Gao X, Lo ECM, Ho SMY, McGrath C, Wong MCM. 2017. Motivational interviewing to promote oral health in adolescents. *J. Adolesc. Health* 61(3):378–84
150. Zaura E, ten Cate JM. 2015. Towards understanding oral health. *Caries Res.* 49(Suppl. 1):55–61

RELATED RESOURCES

AAPD (Am. Acad. Pediatr. Dent.). *Oral health policies and recommendations*. **https://www.aapd.org/research/oral-health-policies--recommendations/**

AHRQ (Agency for Healthc. Res. Qual.). **https://www.ahrq.gov/**

Casamassimo P, Holt K, eds. 2016. *Bright Futures: Oral Health—Pocket Guide*. Washington, DC: Natl. Matern. Child Oral Health Resour. Cent. 3rd ed. **https://www.mchoralhealth.org/pocket/**

CDC (Cent. Dis. Control Prev.). *Oral health*. **https://www.cdc.gov/OralHealth/index.html**

CMS (US Cent. Medicare Medicaid Serv.). *Federally Qualified Health Centers (FQHC)*. **https://www.cms.gov/Center/Provider-Type/Federally-Qualified-Health-Centers-FQHC-Center.html**

Glick M, ed. 2019. *The Oral-Systemic Health Connection: A Guide to Patient Care*. Batavia, IL: Quintessence. 1st ed.

HRSA (Health Resour. Serv. Adm.), US DHHS (Dep. Health Hum. Serv). *Oral health and primary care integration*. **https://bphc.hrsa.gov/qualityimprovement/clinicalquality/oralhealth/index.html**

Lamster IB, Northridge ME, eds. 2008. *Improving Oral Health for the Elderly: An Interdisciplinary Approach*. New York: Springer

NIDCR (Natl. Inst. Dent. Craniofac. Res.), US DHHS (Dep. Health Hum. Serv.). *Health info*. **https://www.nidcr.nih.gov/health-info**

Rural Health Inf. Hub. *Rural Oral Health Toolkit*. **https://www.ruralhealthinfo.org/toolkits/oral-health**