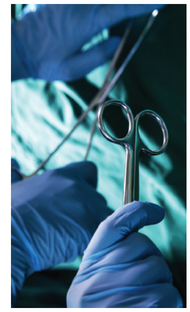


Chapter 10

Dentistry

Richard Niederman, Magda Feres,
and Eyitope Ogunbodede

INTRODUCTION

The oral health chapter in *Disease Control Priorities in Developing Countries*, second edition, focused on noncommunicable disease models for health systems (Bratthall and others 2006). The current chapter provides a complementary approach based on the definition of health care delivery as the "effective provision of services to people with diseases for which proven therapies exist" (Kim, Farmer, and Porter 2013, 1060–61). These complementary approaches—top down and bottom up, respectively—are both necessary; neither alone is sufficient to improve oral health. More specifically, we focus on the effective provision of preventive services and the implications of this goal for global policy changes, and the upstream value and economic choices that must be made to effect these positive changes.

Oral health maladies can be divided into four categories:

- Largely preventable bacterial or viral infections, for example, caries, periodontitis, noma, as well as oral manifestations of HIV/AIDS
- Largely preventable cellular transformations, for example, oral cancer
- Congenital defects, for example, cleft lip and cleft palate
- Trauma.

This chapter addresses the first category—the largely preventable bacterial infections of caries, periodontitis, and noma. It does not specifically address oral-systemic interactions or associations. The other maladies in the remaining three categories are addressed in other chapters and volumes in this series.

We identify evidence-based, cost-effective, preventive interventions that community health care workers can deliver at the community level. These same workers provide better sanitation and clean water, as well as treat a range of diseases, such as diabetes, helminthiasis, HIV/AIDS, malaria, malnutrition, and tuberculosis. These community-based preventive interventions for oral health will increase access to care, improve health, and reduce the burden of disease and the costs of care, compared with traditional surgical approaches to care.

However, in low- and middle-income countries (LMICs), access to the identified services, as well as the financial resources and infrastructure to deliver them, vary. Accordingly, in the initial stages, stakeholders need to be very selective in the starting points.

We specifically selected caries and periodontitis for the following reasons (Marcenes and others 2013):

- They are the first and sixth most prevalent global diseases.
- They are increasing in prevalence because of population growth and aging.

Corresponding author: Richard Niederman, DMD, New York University, rniederman@nyu.edu.

- They are largely preventable bacterial infections of epidemic proportions.

Additional considerations include the following:

- Preventing and controlling these maladies will address the goals of the World Health Organization's (WHO's) Basic Package of Oral Care (Frencken and others 2002).
- Cost-effective preventive measures can be implemented globally (Benzian and others 2012).
- Multiple effective training, workforce, and care models are available to support global implementation (Mathu-Muju, Friedman, and Nash 2013; Nash and others 2012). However, cross-cultural applications will need to be validated.

Like caries and periodontitis, noma is a preventable infection. Unlike caries and periodontitis, which have high prevalence but low morbidity and low mortality, noma has a low prevalence (approximately 0.0005 percent; 0.5 per 100,000), but very high morbidity and mortality (approximately 80 percent) (Marck 2003).

We focus on the critical few preventive measures with demonstrated benefit based on the following:

- Multiple systematic reviews of human trials (caries and periodontitis)
- Multiple human trials exhibiting similar quantitative and qualitative directionality (caries, periodontitis, and noma).

For clarity of purpose, we do not address the other prevention and treatment modalities for which there are no systematic reviews or for which results from human trials differ from one another.

Although we address specific effective preventive measures for oral maladies, these maladies are but one reflection of social determinants of health and disease (Lee and Divaris 2014; Watt 2012; Watt and Sheiham 2012). Other factors include the following:

- Tobacco use (Benedetti and others 2013; Fiorini and others 2014; Walter and others 2012)
- Nutrition (Moynihan and Kelly 2014; Palacios, Joshipura, and Willett 2009; Ritchie and others 2002; Touger-Decker, Mobley, and American Dietetic Association 2007)
- Bidirectional impacts of oral and systemic health (Cullinan and Seymour 2013; Friedewald and others 2009a; Linden, Lyons, and Scannapieco 2013; Lockhart and others 2012).

EPIDEMIOLOGY OF CARIES, PERIODONTITIS, AND NOMA

According to assessments of the WHO and World Bank's Global Burden of Disease (Marcenes and others 2013), untreated caries, or tooth decay, is the most common of all 291 diseases and injuries assessed, affecting 35 percent of the global population. If periodontitis is added to caries, untreated oral maladies affect almost 50 percent of the global population, or 4 billion people. When people with untreated oral maladies are added to those with a history of treatment, oral diseases affect nearly 100 percent of the global population (Marcenes and others 2013).

Caries and periodontitis have the highest prevalence among oral diseases, but other oral diseases add significant morbidity and mortality, including noma, oral manifestations of HIV/AIDs, oral cancer, genetic defects, and orofacial trauma.

Of particular concern is the 11 percent increase of oral diseases between 2000 and 2011, despite the 4 percent decrease in the global burden of other diseases in this period (table 10.1). Quantitatively, and as measured by disability-adjusted life years (DALYs), 15,152,000 years of

Table 10.1 Changes in All Global Burden of Disease Causes and Oral Health, 2000–11

	2011 DALYs (thousands)	Percent change, 2000–11	2011 DALYs (per 100,000 population)	Percent change, 2000–11
All GBD causes	2,744,322	–4	39,553	–16
All oral conditions	15,152	11	218	–3
Untreated caries in primary teeth	5,031	15	73	1
Periodontitis	5,501	27	79	11
Tooth loss	4,620	–7	67	–19

Source: WHO 2013.
Note: DALYs = disability-adjusted life year (years of life lost + years lived with disability); GBD = Global Burden of Disease.

healthy life were lost because of oral conditions in 2011. This loss was almost evenly divided between untreated caries, severe periodontitis, and severe tooth loss.

The largest increases in oral disease occurred in Sub-Saharan Africa (24 percent) and South Asia (19 percent) (table 10.2). Although thought to be due primarily to population growth and aging, increases in caries and periodontitis occurred in almost all LMICs and high-income countries (HICs). Tables 10.3 through 10.5 provide details by region for untreated caries (table 10.3), periodontitis (table 10.4), and tooth loss (table 10.5) (Marcenes and others 2013).

Figure 10.1 illustrates the burden of disease for caries by income level, demonstrating the substantial differences in needs. These differences, in turn, suggest that different approaches to care are required by income level and need, both among and within countries.

MICROBIOLOGY OF CARIES, PERIODONTITIS, AND NOMA

Caries, periodontitis, and noma are largely preventable, mixed, bacterial infections. The specific causative agents for each disease are as follows:

- Caries is a microaerophilic Gram-positive mixture of *Lactobacillus* and several *Streptococci* including *mutans, sanguis, mitis, and salivarius* (Gibbons and van Houte 1975).
- Periodontitis is an anaerobic Gram-negative mixture of *Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis*, *Campylobacter rectus*, *Prevotella intermedia*, *Prevotella nigrescens*, and *Fusobacterium nucleatum* (Haffajee and Socransky 1994; Socransky and Haffajee 1994), and the more

Table 10.2 Changes in Oral Health, by Region, 2000–11

	2011 DALYs (thousands)	Percent change, 2000–11	2011 DALYs (per 100,000 population)	Percent change, 2000–11
World	15,152	11	218	–3
High income	2,467	–2	225	–9
East Asia and Pacific	4,308	14	217	5
Europe and Central Asia	1,242	–6	305	–7
Latin America and the Caribbean	1,502	11	255	–3
Middle East and North Africa	627	14	189	–6
South Asia	3,614	19	219	0
Sub-Saharan Africa	1,392	24	159	–5

Source: WHO 2013.
Note: DALYs = disability-adjusted life years (years of life lost + years lived with disability); GBD = Global Burden of Disease.

Table 10.3 Untreated Caries, 2000–11

	2011 DALYs (thousands)	Percent change, 2000–11	2011 DALYs (per 100,000 population)	Percent change, 2000–11
World	5,031	15	73	1
High income	338	9	31	1
East Asia and Pacific	1,561	10	79	1
Europe and Central Asia	362	1	89	–1
Latin America and Caribbean	349	16	59	2
Middle East and North Africa	245	24	74	2
South Asia	1,581	20	96	1
Sub-Saharan Africa	594	33	68	1

Source: WHO 2013.
Note: DALY = disability-adjusted life year; GBD = Global Burden of Disease.

Table 10.4 Periodontitis, 2000–11

	2011 DALYs (thousands)	Percent change, 2000–11	2011 DALYs (per 100,000 population)	Percent change, 2000–11
World	5,501	27	79	11
High income	915	14	84	6
East Asia and Pacific	1,817	29	91	19
Europe and Central Asia	449	10	110	8
Latin America and Caribbean	635	31	108	14
Middle East and North Africa	177	42	53	17
South Asia	990	34	60	13
Sub-Saharan Africa	518	37	59	5

Source: WHO 2013.
Note: DALY = disability-adjusted life year; GBD = Global Burden of Disease.

Table 10.5 Tooth Loss, 2000–11

	2011 DALYs (thousands)	Percent change, 2000–11	2011 DALYs (per 100,000 population)	Percent change, 2000–11
World	4,620	–7	67	–19
High income	1,214	–13	111	–20
East Asia and Pacific	930	–4	47	–11
Europe and Central Asia	432	–22	106	–23
Latin America and the Caribbean	518	–8	88	–20
Middle East and North Africa	205	–10	62	–25
South Asia	1,043	6	63	–10
Sub-Saharan Africa	279	–7	32	–29

Source: WHO 2013.
Note: DALY = disability-adjusted life year; GBD = Global Burden of Disease.

recently identified or renamed *Aggregatibacter actinomycetemcomitans*, *Tannerella forsythia*, and *Treponema denticola*.

- Noma exhibits an altered oral microbiota with an increase in *Prevotella* and *Peptostreptococcus* genus exacerbated by poor nutrition, poverty, and prior infections (Huyghe and others 2013; Paster and others 2002).

CARIES

Traditional Surgical Treatment

For more than 100 years, dentists have successfully treated dental cavities with surgery, consisting of local anesthesia, followed by surgical excision of the decay, followed by filling. To ensure success, surgical excision normally extended beyond the lesion itself as a preventive measure against further decay. This approach is termed extension for prevention, or comprehensive treatment (Webster 1908). The clinical principle was that, to ensure success, all decay and all areas of potential decay had to be removed. Once this was done, additional tooth structure was removed to provide undercuts that mechanically hold the "permanent" fillings (usually silver amalgam) in place. These permanent fillings, however, have a limited life span of approximately 10 years and then require replacement (Burke and Lucarotti 2009; Chadwick and others 2001; Downer and others 1999).

The traditional surgical approach to care is office based; patients travel to dental offices multiple times for comprehensive care. Additionally, systematic reviews demonstrate that traditional fillings, with extensive excision of tooth structure, lead to a significant increase in risk of adverse events, when compared with sealing early caries lesions or providing atraumatic restorations (Ricketts and others 2013; Schwendicke, Dörfer, and Paris 2013).

There exist little or no data to demonstrate that traditional surgical care followed by fillings reduces or prevents the underlying causative infection from instigating further tooth destruction. Accordingly, the identification of causative bacterial agents, together with the identification of a number of preventive and treatment agents, led to the twenty-first-century concept, and first clinical demonstration, of minimal intervention dentistry (Frencken and others 1994).

Finally, this chapter's focus on prevention precludes discussion of surgical care (such as fillings and extractions). We recognize that fillings for treating cavities have an established history (Webster 1908); extractions for acute problems are essential components of the WHO's Basic Package of Oral Care (Frencken and others 2002), and extractions are an integral part of emergency and trauma care. However, work on both the longevity and the cost of fillings, compared with prevention, indicates that investments in prevention outweigh investments in fillings (Mickenautsch and Yengopal 2012; Mickenautsch, Yengopal, and Banerjee 2010; Ricketts and others 2013; Schwendicke and others 2013).

Preventive Approaches

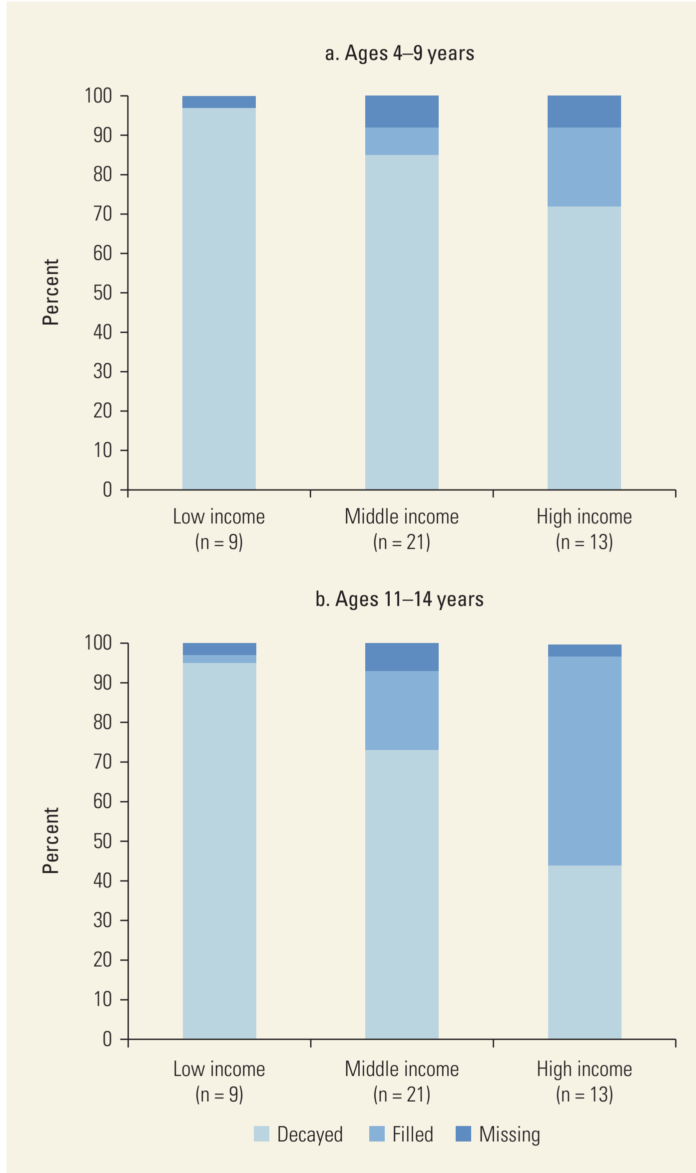
Multiple systematic reviews of human randomized controlled trials from multiple LMICs and HICs have identified a number of effective caries prevention agents (table 10.6). In all cases, preventive care can be community based, in addition to office or clinic based, allowing care to be brought to patients rather than patients brought to care. Furthermore, because the biology of caries is identical globally and across the life span, the mode of action and efficacy of these agents are also similar. However, because of training deficiencies, tariffs, local regulations, and social infrastructure, the delivery of these evidence-based, cost-effective preventive therapeutics varies substantially among countries and within countries.

Systematic reviews with formal comparative comprehensive economic evaluations of all caries prevention methods are modest in both number and quality (Källestål and others 2003; Mariño, Khan, and Morgan 2013). The available work indicates that for specific countries, and for specific populations, prevention is cost-effective. However, many of these evaluations fall short of current economic evaluation standards. Accordingly, only estimated efficacy and costs are provided in table 10.6 to facilitate local assessments.

Water Fluoridation. High-quality economic evaluations of water fluoridation conducted in Australia and the United States for the general and aging populations indicate reductions in caries greater than 20 percent to 50 percent for approximately US$0.50 per year per person (Campain and others 2010; Doessel 1979; Griffin, Jones, and Tomar 2001; Johnson and others 2014). A caution is warranted because these studies use differing methodologies and may not relate to LMICs (Mariño, Khan, and Morgan 2013).

Studies of water fluoridation have been carried out in LMICs. Two examples of import provide object lessons on its benefits. In Brazil, a 25-year longitudinal assessment of caries demonstrates a significant

Figure 10.1 Proportion of Decayed, Missing, and Filled Teeth in Children, by Income Level, 1990–2004



Source: Yee 2008.

Table 10.6 Summary of Current Systematic Reviews: Identifying Effective Caries Preventive and Therapeutic Agents

Agent	Frequency	Estimated efficacy (percent)	Material cost[a] US$	Material cost[a] US$ per year	Delivery agent
Water fluoridation	Continuous	20–40[1]		$0.50[2]	Piped water
Salt fluoride	Daily	20[3]		$0.03[4]	Cooked food
Fluoride toothpaste[b]	Twice a day	25[5]	< $0.05 per dose	$0.50–36.50[6]	Individual or school
Fluoride milk	More than twice a day	>20[7]	n.a.	n.a.[8]	Individual
Silver fluoride	Twice a year	80[9]	$0.10 per dose	$0.20	Community health care worker
Fluoride varnish	More than twice a year	40[10]	$3.00 per dose	$6.00[11]	Community health care worker
Sealant	Once for posterior tooth	80[12]	$3.00 per application on multiple teeth		Community health care worker
Atraumatic restoration (therapeutic sealant)	As needed	80[13]	$3.00 per application on multiple teeth[14]		Community health care worker
Filling	As needed	80[13]	$2.00 per anesthesia and filling per tooth		Community health care worker or dentist
Extraction	As needed	100	$1.00 per tooth for anesthesia		Community health care worker or dentist

Sources:

1. Griffin and others 2007; Johnson and others 2014; McDonagh and others 2000; Parnell, Whelton, and O'Mullane 2009.
2. Kroon and van Wyk 2012b; Mariño, Fajardo, and Morgan 2012; van Wyk, Kroon, and Holtshousen 2001.
3. Yengopal and others 2010.
4. Gillespie and Marthaler 2005; Mariño, Fajardo, and Morgan 2012; Marino and others 2011.
5. Dos Santos, Nadanovsky, and de Oliveira 2012; Wong and others 2011.
6. Benzian 2012; Davies and others 2003; Splieth and Flessa 2008; Yee, McDonald, and Walker 2004.
7. Cagetti and others 2013; Espelid 2009.
8. Mariño, Fajardo, and Morgan 2012.
9. Liu and others 2012; Rosenblatt, Stamford, and Niederman 2009; Zhi, Lo, and Lin 2012.
10. Marinho and others 2013.
11. Hendrix and others 2013; Quiñonez and others 2006; Sköld and others 2008.
12. Ahovuo-Saloranta and others 2013; Mickenautsch and Yengopal 2011; Yengopal and others 2009.
13. de Amorim, Leal, and Frencken 2012; Mickenautsch and Yengopal 2011; Ricketts and others 2013; Schwendicke, Dörfer, and Paris 2013.
14. da Mata and others 2014; Schwendicke and others 2013.

Note: n.a. = not available.

a. Only includes actual material cost for active agent, not ancillary material costs (for example, toothbrush, applicators, sterile instruments, gloves, and barriers to deliver active agents), or indirect costs (for example, transportation and rent).

b. Systematic reviews support an international standard level of 1,000 parts per million fluoride for younger children and up to 1,500 parts per million for older children and adults (Wong and others 2011).

25 percent reduction in caries over five years following water fluoridation (Lauris, da Silva Bastos, and de Magalhaes Bastos 2012) at a cost of approximately US$0.03 per year per person (Frias and others 2006). Routine assessments of water fluoride levels were needed to ensure success (Buzalaf and others 2013; Moimaz and others 2012; Moimaz and others 2013). In South Africa, a Commission of Inquiry recommended community water fluoridation with regulations compelling water fluoridation. However, the water remains unfluoridated, despite multiple economic analyses demonstrating that water fluoridation can reduce caries by approximately 15 percent at a cost of approximately US$0.36 per year per person and is cost-effective (Kroon and van Wyk 2012a, 2012b; van Wyk, Kroon, and Holtshousen 2001).

Water fluoridation depends on the availability of potable piped water. However, even when fluoridated water is available, it is not 100 percent effective. Implementation of complementary effective fluoride delivery systems and preventive measures need to be considered to control and prevent caries. Efficacy studies have been carried out in LMICs for all of these fluoride delivery systems and preventive interventions (table 10.6); they are likely to be effective at local levels if affordable high-quality products are available.

Modeling and subsequent testing of the projected economic costs to achieve these health benefits need to be locally determined. Some examples from LMICs, UMICs, and HICs are relevant (Mariño, Khan, and Morgan 2013; Morgan and others 2012). Focused studies of salt fluoridation in Peru (Marino and others 2011), toothpaste in Nepal and Brazil (Frazao 2012; Yee, McDonald, and Helderman 2006; Yee, McDonald, and Walker 2004), and comparative studies in Chile (Mariño, Fajardo, and Morgan 2012) differ in methodology; however, all demonstrate the tangible clinical and economic benefits of salt, water, toothpaste, and milk fluoridation.

PERIODONTITIS

Periodontitis is an inflammatory reaction to an overgrowth of a mixed, anaerobic bacterial infection colonizing the subgingival crevices around the teeth. If untreated, this infection leads to bleeding gingiva, loose teeth, and ultimately, tooth loss. In addition, this inflammatory reaction is associated with adverse effects on systemic health (Han and others 2014). These include, for example, cardiovascular disease (Friedewald and others 2009b; Tonetti, van Dyke, and Working Group 1 2013), diabetic control (Borgnakke and others 2013), and adverse pregnancy outcomes (Ide and Papapanou 2013; Sanz, Kornman, and Working Group 3 2013).

Paradoxically, most of the bacterial species present in the oral biofilm are host-compatible or beneficial (Socransky and others 1988; Socransky and others 1998). These bacteria not only inhabit the subgingival crevice; they are also found on the supragingival tissue, tongue, cheek, and palate (Faveri and others 2006; Mager and others 2003). Thus, health or disease is a result of the balance or imbalance in the oral microbiome (Socransky and Haffajee 2002; Teles, Haffajee, and Socransky 2006).

Current data support the concept that clinical improvement is attained when there is a change from a disease-related to a health-related oral ecology (Feres 2008; Socransky and Haffajee 2002; Teles, Haffajee, and Socransky 2006). To achieve this shift, effective therapy needs to address all the oral ecological environments.

Similar to dental caries, periodontitis has been successfully treated with mechanical therapy for more than 100 years, including scaling and root planing with or without subsequent surgery. Furthermore, successful therapy requires quarterly maintenance therapy. It is of interest to note that we were unable to identify studies demonstrating beneficial long-term impact on the oral microbiome following mechanical therapy.

Two levels of care are potentially effective in the treatment of gingivitis: patient-applied toothpastes and mouthwashes, and professionally prescribed antimicrobials (Teles and Teles 2009). Gingivitis is generally considered to be a precursor to periodontitis, and patient-applied oral use of specific mouthwashes and toothpaste can potentially reduce risk of subsequent periodontitis. The agents that provide a clinically significant benefit in reducing gingivitis are triclosan copolymer toothpaste and chlorhexidine mouthwash (Gunsolley 2006; Osso and Kanani 2013; Riley and Lamont 2013; Van Strydonck and others 2012).

Seminal Clinical Trials

Three seminal trials provide key turning points and offer an alternate approach to periodontal mechanical therapy—the use of combination therapy with metronidazole and amoxicillin (250–500 milligrams of each agent, three times a day, for seven days). The first trial was a case series of 118 patients who, having failed all forms of traditional mechanical therapy, received metronidazole and amoxicillin and scaling (van Winkelhoff, Tijhof, and de Graaff 1992). The second trial was a masked randomized controlled trial of 46 patients that compared metronidazole and amoxicillin to placebo (López and Gamonal 1998). Perhaps the most surprising of all the studies, but with multiple threats to validity, was the paradigm-breaking solitary study comparing a seven-day regimen of metronidazole plus amoxicillin alone to scaling or root planing alone (López and others 2006). At 12 months, the clinical and microbial outcomes of care for patients receiving antimicrobial therapy alone were similar to those of patients receiving only mechanical therapy. In sum, in all three cases, seven days of metronidazole and amoxicillin shifted the oral ecology from disease-related to health-related and improved clinical health, compared with prior or concurrent mechanical therapy.

Systematic Reviews

Three systematic reviews of human randomized controlled trials examined combined short-term metronidazole plus amoxicillin for treating periodontitis. The results of all three reviews found significant statistical and clinical benefit of short-term (7–14 days) 250–500 milligram metronidazole and amoxicillin three times a day (Sgolastra, Gatto, and others 2012; Sgolastra, Petrucci, and others 2012; Zandbergen and others 2013).

Recent Clinical Trials

Human randomized clinical trials, published after the inclusion dates of these systematic reviews, support the use of short-term metronidazole and amoxicillin (Feres and others 2012; Goodson and others 2012; Mestnik and others 2010). Although these studies differed from each other in important ways, they reached similar conclusions: antibiotic therapy shifts the oral microbiome from disease related to health related, with substantial clinical improvement. Feres and others (2012) treated high-risk patients, Mestnik and others (2010) treated patients with aggressive disease, and Goodson and others (2012) treated patients with moderate to high disease levels. These trials demonstrate that short-term treatment with metronidazole and amoxicillin achieved the following outcomes:

- The combination therapy moved 66 percent of patients from high-risk levels to low-risk levels one year after therapy; in contrast, mechanical therapy only moved 22 percent of patients from high-risk levels to low-risk levels (Feres and others 2012).
- The combination therapy was more clinically effective than mechanical therapy in patients with aggressive periodontitis (Mestnik and others 2010).
- The combination therapy resulted in better microbial and clinical outcomes two years after therapy, compared with other treatments, for example, scaling and root planing, surgery, scaling and root planing plus surgery, and local antibiotic delivery (Goodson and others 2012).

Concerns with Antimicrobial Use

The studies described all support the demonstrated sustained clinical and statistical improvements in periodontal health in subjects receiving short-term metronidazole in combination with amoxicillin. However, antibiotic use in a public health context raises concerns about several issues: the quality, affordability, and availability of the antibiotics; resistance to the antibiotics as well as the emergence of resistant-strains of bacteria; and changes or reequilibration of the oral (and gastrointestinal) microbiome.

Multiple perspectives merit consideration:

- *Risks versus benefits.* The benefits need to clearly offset the risks. The benefits of short-term metronidazole plus amoxicillin in treating periodontitis must secure benefits that would be much more difficult, costly, inaccessible, or risky by other means, such as surgery with quarterly cleaning.
- *Recolonization.* Treating periodontitis with metronidazole plus amoxicillin facilitates oral recolonization by a health-compatible oral microbiome (Matarazzo and others 2008; Silva and others 2011).
- *Acquired resistance.* Resistance to metronidazole has rarely been reported (Soares and others 2012).
- *Allergic reactions.* Assessments vary, but current data suggest a prevalence of approximately 37 percent for nonsteroidal anti-inflammatory drugs and 5 percent to 29.4 percent for beta-lactam antibiotics (Bigby and others 1986; Dona and others 2012). Clindamycin and azithromycin are alternatives (Herrera and others 2008).
- *Global increase in antibiotic resistance.* The dramatic and effective use of metronidazole plus amoxicillin for treating *Helicobacter pylori* and the global increase in resistance provides a useful object lesson. In Latin America, amoxicillin resistance is approximately 4 percent, and metronidazole resistance is approximately 53 percent (Camargo and others 2014). Early short courses of combination therapy with the two antibiotics prevent the emergence of resistant strains (D'Agata and others 2008).
- *Relative balance (known and unknown) of direct benefits and risks.* Preliminary data suggest that antimicrobial use changes the human microbiome in the direction of increasing the risk of obesity, type 1 diabetes, inflammatory bowel disease, allergies, and asthma (Blaser 2011). Conversely, data also indicate that treating periodontitis with metronidazole plus amoxicillin facilitates oral recolonization by the health-compatible oral microbiome (Matarazzo and others 2008; Silva and others 2011). The potential benefits of effectively treating periodontal infections include reductions in the negative impacts that the inflammatory response has on cardiovascular disease, diabetes, and pregnancy outcomes (Borgnakke and others 2013; Friedewald and others 2009b; Ide and Papapanou 2013; Sanz, Kornman, and Working Group 3 2013; Tonetti, van Dyke, and Working Group 1 2013).

In sum, the most effective approach to controlling and preventing periodontitis appears to be short-term metronidazole and amoxicillin, with or without concordant mechanical therapy. However, in countries without access to professional treatment, metronidazole and amoxicillin alone may be the only effective and efficient option. This assumption will need rigorous testing under local conditions for widespread validation. The additional potential benefits of local testing will be the secondary benefits of improved systemic health. The alternative to testing is the absence of care or the implementation of mechanical therapy, which is more expensive and less effective.

Additional Considerations

Two additional points relevant to systemic health are noteworthy with respect to the available data.

First, we were unable to identify any human trials supporting the concept that a single round of mechanical therapy alone (for example, scaling and root planing, with or without surgery) will prevent or control periodontal infections or improve oral health in the long term (Loesche and Grossman 2001; Sampaio, Araújo, and Oliveira 2011; Worthington and others 2013). This lack of support was not unexpected. Mechanical therapy targets specific tooth surfaces but does not comprehensively address other areas of microbial residence, such as tongue and oral mucosal; nor is mechanical therapy capable of removing residual disease-related microbial colonies from the treated tooth surfaces.

Second, only a few studies address the economics of mechanical periodontal therapy, and these indicate that scaling and root planing do not confer an economic benefit (Braegger 2005; Gaunt and others 2008). In light of the enhanced clinical benefit of antimicrobial intervention (with or without scaling and root planing), the wider opportunity for intervention and access to care provided by nondental personnel, the broader potential beneficial impact of antimicrobials on systemic disease, and the broader potential negative impact on antimicrobial resistance, we await demonstration programs examining the clinical and economic impact of antimicrobial therapy.

NOMA

Noma (cancrum oris, necrotizing ulcerative gingivitis, stomatitis gangrenosa) is a destructive ulceration of the gingival-oral mucosa that spreads extraorally, degrading the tissues of the face and bone (Ogbureke and Ogbureke 2010). The disease leads to severe destruction of the midface—the lips, cheek, maxilla, mandible, nose, and orbital floor—with unsightly facial disfigurement, impaired self-nutrition, impaired speech, trismus, and social alienation (Marck 2003; Ogbureke and Ogbureke 2010).

Prevalence and Incidence

Noma is most commonly found in Sub-Saharan Africa, where extreme poverty, malnutrition, and childhood infections are common (Feller and others 2014). Noma is commonly described as the "face of poverty" because of its facial location and prevalence among children ages one to four years in LMICs (Marck 2003). Estimates suggest a global prevalence of 500,000 people; an annual incidence of 140,000; and a mortality rate of 80 percent to 90 percent (Bourgeois and Leclercq 1999). In local regions of Nigeria, the incidence is estimated to reach 6.4 per 1,000 children, which extrapolates to a global incidence of 30,000 to 40,000 (Fieger and others 2003). However, these estimates are based on cases and projections and may overestimate or underestimate the prevalence and incidence.

Contributing Factors

The precipitating events are unclear. The most recent and best studies are a matched and powered case control and a parallel microbial analysis. They indicate three contributing factors:

- An altered oral flora, specifically an increase in the percentage of *Prevotella* and *Peptostreptococcus* genus, and a decrease in the percentage of *Fusobacterium*, *Capnocytophaga*, *Neisseria,* and *Spirochaeta*
- Malnutrition
- Recent illness of respiratory or intestinal origin or compromised immune response, for example, the presence of HIV/AIDS (Baratti-Mayer, Pittet, and Montandon 2004; Bolivar and others 2012; Feller and others 2014).

Treatment

When detected early, noma responds to antibiotic treatment with metronidazole plus amoxicillin. Recommended doses vary with age and body weight; they range from 100 milligrams to 500 milligrams of each agent three times per day for seven days. When antibiotics are used in conjunction with nutritional rehabilitation, the mortality rate drops from more than 80 percent to less than 10 percent (Baratti-Mayer, Pittet, and Montandon 2004; Bolivar and others 2012; Tempest 1966). These findings support a bacterial and nutritional etiology.

For survivors, postinfection surgical reconstruction, when available, is extensive. No standardized approach can be advocated because of the variety of anatomical manifestations (Marck and others 2010). The current consensus is that surgical techniques will largely depend on the extent and location of the lesions, the availability of technical facilities, the competence of the surgical teams, and the timing of surgery (Ogbureke and Ogbureke 2010).

Treatment normally consists of excising all scar tissue, correcting the trismus, raising and transposing local and distant soft tissue flaps, and bone grafting in cases of considerable loss of facial bone or jawbone. Multiple flap, transposition, and closure designs have been implemented, often paralleling oncologic reconstruction.

Reconstruction for noma, however, differs from oncologic reconstruction in several ways (Huijing and others 2011):

- Compound tissue losses are common.
- The bony defect and soft-tissue scar affect facial skeleton and dental development, producing gross asymmetry, with loss of normal anatomical reference points.
- Patients usually suffer nutritional deficiencies and extreme deprivation.
- Postoperative complications, such as poor healing and infection, are common.

Even in the most advanced medical environments, however, the results of surgical repair are less than perfect (Bisseling and others 2010; Bouman and others 2010), but preoperative planning, multiple staged surgeries, and a multidisciplinary team approach have been found to be useful in reducing postoperative complications (Huijing and others 2011; Marck and others 2010). These include the following precautions:

- Postponement of surgical treatment until the acute phase has abated
- Routine presurgical clinical workup, including dental care, hyperalimentation, multivitamin and anthelminthic treatment, and general hygiene measures
- Multidisciplinary team approach of plastic and maxillofacial surgeons, orthodontists, pedodontists, prosthodontists, physical therapists, and psychologists.

Additional studies demonstrate the benefits of anesthesiologists who can provide special airway and ventilation techniques needed for the limited openings (Coupe and others 2013), as well as psychiatric support and societal reintegration (Yunusa and Obembe 2012).

Economic analysis of this care is unavailable, possibly because of the low prevalence, high morbidity, and variability and complexity of care.

IMPLICATIONS FOR GLOBAL HEALTH POLICY

The oral diseases discussed in this chapter are preventable global epidemics that affect more than 50 percent of the population and have increasing prevalence (Marcenes and others 2013). The systematic reviews and clinical studies cited indicate that effective preventive measures are available. However, effective dissemination and implementation that improve oral health depend on two complementary approaches: a top-down noncommunicable disease model (Bratthall and others 2006), and a bottom-up health care delivery model (Kim, Farmer, and Porter 2013). In marked contrast to the traditional surgical model of oral care, these preventive measures can be delivered outside of clinical settings by community health workers (Benzian and others 2012; Monse and others 2010; Nash and others 2012).

Delivery Models for Prevention

The widespread incidence and increasing prevalence; the attendant long-term detrimental educational, medical, and social effects; the absolute and relative inequalities in care for HICs as well as LMICs (and within countries); and the collocation of these diseases with other noncommunicable diseases combine to suggest that it is appropriate to consider alternative approaches to traditional surgical care delivered by dentists.

Prevention Choices. Nationally, regionally, and locally, the preventive choices and modes of delivery will vary. These variations will depend on local needs, values, circumstances, and infrastructure, as well as on product availability and cost (box 10.1). Furthermore, if the goal is sustainable, long-term improvements in oral health, then systemic changes will be required at all stakeholder levels: patients, care providers, organizations, and governments. These evidence-based, effective, preventive methods will need to be culturally integrated into the social systems of personal care, care-provider training, and workforce models, as well as into community-based care delivery, compensation, and incentive systems.

Elements of a High-Value Program. An effective population- and patient-centered delivery framework is hypothesized to have four elements essential to delivering and optimizing value (Kim, Farmer, and Porter 2013; Porter 2010; Porter, Pabo, and Lee 2013):

- Integration of care for every individual condition over the cycle of care
- Shared delivery infrastructure across medical conditions
- Implemented knowledge of local patient and community constraints
- Maximized equitable economic and community development to improve value.

Delivery Choices. Oral prevention could be delivered in three ways, depending on local values, circumstances, infrastructure, and product availability:

- By patients themselves, for example, by the use of *affordable* fluoridated toothpaste and fluoride salt

Box 10.1

Guidelines for Selecting and Implementing the Basic Package of Oral Care

Guidelines for selecting and implementing the Basic Package of Oral Care (BPOC) in LMICs follow. The selection of interventions will be determined locally, regionally, and nationally.

Examples of partial implementation of the BPOC:

- **Cambodia:** Training of rural nurses to provide simple extractions, draining of abscess under local anesthesia, and atraumatic restorative treatment (Chher and others 2009).
- **Nepal:** Implementation of affordable toothpaste resulted in 27 percent decrease in caries prevalence and 10 percent decrease in oral pain (Yee, McDonald, and Helderman 2006).
- **The Philippines:** Training of teachers and education staff members to implement hand washing, fluoride tooth brushing, and school deworming programs (Monse and others 2013).
- **Tanzania:** Training of primary health care workers in the provision of simple extractions and atraumatic restorative treatment, resulting in improved oral health and quality of life (Kikwilu, Frencken, and Mulder 2009; Mashoto and others 2010).

Barriers to Implementing the BPOC:

- An absence of knowledge of the BPOC among government entities, nongovernmental organizations, and clinicians collaborating to improve oral health
- Knowledge of the BPOC, but failure to accept its utility based on the perceived absence of evidence, advantage, simplicity, compatibility with values, and trust in concept
- Acceptance of BPOC, but an absence of methodological knowledge of implementation and improvement, or determination of how BPOC might be integrated into existing health or educational structures
- A reluctance on the part of the dental profession to accept oral care provision by ancillary personnel.

Implementation precepts:

- **Safe:** Care should be as safe for patients in health care facilities as in their homes.
- **Effective:** The science and evidence behind health care should serve as the standard in the delivery of care and be applied.
- **Efficient:** Both process and outcomes of care should achieve maximum outcome with minimal time, effort, or expense.
- **Timely:** Patients should not experience excessive delays in receiving care and service.
- **Patient centered:** The system of care should be patient centered, respect patient preferences, and put patients in control.
- **Equitable:** Disparities in care should be eliminated.
- **Feasible:** The initiating clinical, organizational, or governmental stakeholders should have the financial, organizational, technical, capacity, and collaborative commitments to implement the programs.
- **Sustainable:** The delivery system must be financially, organizationally, and technically sustainable.
- **Improvement:** Process and outcome measures should be systematically implemented and the results evaluated to reduce waste and variation.
- **Regulatory compliance:** Compliance with all local and national regulations should be ensured.
- **Communicated outcomes:** Outcomes must be disseminated to overcome implementation barriers.

Implementation Steps

Step 1. Ask three questions:

- What is to be improved at the local, regional, or national level?
- What change will be made?
- How will we know that the change effected improvement?

box continues next page

Box 10.1 (continued)

Step 2. Determine local, regional, or national needs and capacities:

- Oral health needs (to see if implementation is needed)
- Costs and availability of funding
- Availability of necessary supplies, personnel, and collaborating health groups
- Quality of supplies

Step 3. Develop improvement plan to accomplish the following:

- A pilot program manual of procedures
- Carrying out of pilot
- Evaluation of impact (for example, Reach multiplied by Effectiveness for patient-centered outcomes)
- Identification and reduction of waste and variations

Step 4. Develop improvement plan to accomplish the following:

- Scale up effective pilot programs
- Evaluate wider impact validity
- Evaluate fidelity of adoption and maintenance

Sources: Chher and others 2009; Glasgow and others 2005; Greenhalgh and others 2004; IHI 2014; IOM 2001; Kikwilu, Frencken, and Mulder 2009; Langley and others 2009; Mashoto and others 2010; Monse and others 2013; Rogers 2002; Yee, McDonald, and Helderman 2006.

- By nondentist community health workers and school systems, for example, by the provision of fluoride toothpaste, silver fluoride, fluoride varnish, sealants, atraumatic restorations, antibiotics, and improved nutrition
- By community-wide programs and capacities, for example, the provision of water fluoridation and fluoride salt.

Of the three ways, the modest training of community health workers and school system staff, and the expansion of their current services, may provide the most immediate opportunity for oral health care improvement. Community water fluoridation is perhaps the most cost-effective preventive measure for caries, but it requires the most significant prior systematic infrastructure—piped potable water. Until such infrastructure exists, mobile clinics that bring dental services to rural communities may be cost-effective solutions for secondary prevention, such as restorative care, as demonstrated in South Africa and Thailand (Holtshousen and Smit 2007; Tianviwat, Chongsuvivatwong, and Birch 2009). For individual community-based care, affordable fluoridated toothpaste needs to be locally available for home use.

At least two narrative and two systematic reviews support the community-based delivery of preventive oral health care by nondentists (Calache and Hopcraft 2012; Mathu-Muju, Friedman, and Nash 2013; Nash and others 2012; Wright and others 2013). These studies indicate that community health care workers can increase access to care, improve health, and reduce costs by eliminating the proximal need for dentists. Much of the data in table 10.6 come from studies employing community health workers. Local values and circumstances will guide decisions, and local pilot and scaling programs will be required to quantitatively validate local process and outcome effectiveness.

One example of the beneficial and significant impact of an integrated community-based care program using a noncommunicable disease model is the award-winning Fit for School program in the Philippines. This program marries once-a-year school-based deworming with school-based tooth brushing with fluoridated toothpaste (box 10.2) (Benzian 2012; Benzian and others 2012; Monse and others 2010).

Fit for School parallels numerous improvement initiatives in LMICs (see box 10.1 for oral health examples). These initiatives include agriculture, education, environment, finance, governance, labor, and health. Many of these effective programs are chronicled in Banerjee and Duflo (2011). This work ranges from evaluating effectiveness, building capacity, and changing policies for deworming, bed nets, and chlorine in Kenya; to water disinfectants in Zambia; to hand washing with soap in India and Pakistan.[1]

Fees. Among the key counterintuitive policy findings is that the evidence does not support the practice of charging small fees to poor people for health products and

Box 10.2

The Fit for School Approach

The Philippine Department of Education, supported by the German Enterprise for International Cooperation, the Philippine *Fit for School Inc.,* and other partners, initiated the Essential Health Care Program (EHCP) in public elementary schools. The program is based on the Fit for School Approach and integrates three evidence-based prevention measures for the most prevalent childhood diseases: soil-transmitted intestinal worm infections, hygiene-related diseases such as diarrhea and respiratory infections, and rampant tooth decay.

The program implements the following activities run by teachers:

- Daily group hand washing with soap
- Daily group tooth brushing with fluoride toothpaste
- Biannual deworming according to the WHO guidelines

These evidence-based interventions are complemented by the construction of facilities for group hand washing and sanitation and the provision of clean water to schools without access to it. The EHCP currently reaches more than 2.5 million Filipino children and is also implemented in Cambodia, Indonesia, and the Lao People's Democratic Republic. Material costs average US$0.50 per child per year. Affordability increases the probability that this program can be integrated into the regular government budgets, even in resource-poor countries, thereby ensuring sustainability beyond the initial start-up costs.

Sources: Benzian 2012; Monse and others 2013.

services, a policy promoted to help reduce waste. Even small fees for prevention services substantially reduce use. This finding suggests that prevention programs should be provided at no charge to patients and should be sustained by governmental funding.[2]

Examples, Principles, and Guidelines. Box 10.1 provides examples of programs implementing the Basic Package of Oral Care, as well as the principles and guidelines for selecting and implementing prevention programs.

Lessons Learned from Current Care Delivery Models in High-Income Countries

The unchanging high oral health needs in the United Kingdom and the United States provide the counterfactual to focusing on traditional surgical rather than preventive care.

In the United Kingdom, 33 percent of children age five years have active decay, and 2.3 percent have sepsis (NHS 2007). The need for care extends to adults: 31 percent have untreated cavities, 22 percent have urgent conditions, and 9 percent have dental pain (NHS 2009). The reviews of National Health Service dental care during the past 30 years repeatedly call for increases in both prevention and access to care, and for reductions in both the inequality of service distribution and waste through overuse, underuse, and misuse of services (NHS 2005; Steele 2009).

In the United States, the Healthy People initiative reports that, from 1990 to 2010, the percentage of studied children with untreated decay remained virtually unchanged at almost 30 percent.[3] For underserved, rural, and minority populations, the percentage is significantly higher, reaching almost 50 percent (Dye and Thornton-Evans 2010). During the same period, yearly governmental dental expenditures for children increased from US$1 billion to US$7 billion. Spending is expected to reach US$15 billion by 2020 (CMS 2011b). In parallel, national spending for oral health care reached US$105 billion in 2010 (CMS 2011b). This level is second only to that of cardiac care (AHRQ 2007) and is expected to be US$170 billion by 2020 (CMS 2011b). Yet, data from the national Healthy People initiative indicate that oral health is not improving in concert with spending.[4] As a result, the need for a change to prevention-focused care is chronicled in multiple government and foundation publications (CMS 2011a; HHS 2010; IOM 2011a, 2011b).

Dental Workforce

The immediate need for considering alternatives to the current surgical-mechanical model of care is also clear when the current dental workforce is taken into account.

The 188 countries for which there are data have, on average, 0.3 (plus or minus 0.4 standard deviation) dentists per 1,000 residents (WHO 2006). The United States, which has five times the global average, has not been able to improve oral health during the past 20 years.[4]

These findings suggest that new education, training, and workforce models are needed (Bhutta and others 2010; Frenk and others 2010; Mathu-Muju, Friedman, and Nash 2013; Nash and others 2012). The current surgical-mechanical care model will not solve the global oral health problem. Countries need two complementary prevention frameworks for improving oral health care:

- A community-based health care provider model for providing services to people with diseases for which proven therapies exist (Kim, Farmer, and Porter 2013)
- A noncommunicable disease model (Bratthall and others 2006).

To succeed, the community-based health care worker model will need to consider the following:

- Preventive care delivered by nondentists
- Triage prevention, extractions, and complex surgical care
- Innovative methods to increase access to care at all levels, such as focused prevention integrated with other health initiatives, and focused mobile extraction service, to overcome the many barriers to access to safe oral health care.

Quality of Care

The Institute of Medicine's report *Crossing the Quality Chasm* identified six quality aims for clinical care (IOM 2001). From this perspective, using surgery rather than prevention as the primary mode of dental care seems to violate five of the six quality aims. This is not to say that surgery is unsafe or unwarranted; clearly, it is critical for treatment of acute abscesses, extractions, and noma.

However, for the most common infections—caries and periodontitis—surgical care appears to have the following limitations:

- It is not effective in treating the underlying causative infection.
- It is not patient centered in that clinicians are well compensated to intervene surgically but patients are better served by prevention.
- It is not timely in that multiple appointments, travel, and missed work or school are required to treat multiple teeth.
- It is not efficient in that surgical care requires a dental office, and preventive care can be delivered in locations where people learn, work, play, or pray.
- It is not equitable in that care is available only to people who are geographically near clinics, have a means of transportation, and can pay for care.

The surgical approach provides an example of the overuse of ineffective treatment and the underuse of effective prevention (Kohn, Corrigan, and Donaldson 2000).

INCREASING CLINICAL VALUE WITH COMMUNITY-BASED PREVENTION

A conceptual strategic starting point for thinking about alternative care models is value-based oral health care. *Value for global health care delivery* is defined as the aggregate health outcomes per aggregate costs (value = outcomes divided by costs) (Kim, Farmer, and Porter 2013; Porter 2010; Porter, Pabo, and Lee 2013). Outcomes depend on patient results rather than process measures such as numbers of patients seen and procedures completed.

Work from multiple groups (IOM 2013; Kaplan and Porter 2011; Porter 2010; Schoen and others 2013), an international comparison of 12 countries (Soderlund and others 2012), and assessments of oral health care (Glassman 2011) all indicate that focusing on values can be a key driver for health improvement. The goal is to simultaneously address a set of interrelated patient circumstances for a distinct population with distinct prevention and care challenges using an integrated and shared delivery infrastructure to improve health and reduce costs.

Value can be increased in two ways: by continually implementing the current best evidence to improve outcomes, and by reducing the costs accruing from waste and variation. In short, value can be improved by implementing safe, effective, patient-centered, timely, efficient, and equitable care (Kohn, Corrigan, and Donaldson 2000).

Outcomes

With the exception of noma, for which only case series are available, the data cited all derive primarily from systematic reviews of studies done in LMICs; the reviews indicate that the success rates for prevention are equivalent to or exceed those for surgery. For noma, the available data indicate that population-based and immediate prevention is more effective than surgery.

These comments are independent of the geographic location, the patient age, and the longevity of the study. The findings for caries and periodontitis contradict the conventional clinical thinking and training, which tend to focus on the individual clinical techniques of comprehensive surgical treatment and overlook community-based comprehensive prevention.

Short-Term Costs

In the traditional clinical setting, short-term costs accrue directly and indirectly. Surgically related direct costs for personnel, equipment, and supplies are all substantially higher than those associated with preventive care delivered by community health workers, plus prevention supplies, and antibiotics. Similarly, the indirect costs for surgery (for example, office space rent; utilities; patients' travel to dental offices or hospitals; and time away from work, school, and family, and for multiple visits) are all substantially higher than prevention delivered in community locations. Although the absolute costs may vary among LMICs, we suspect that the relative cost differentials are similar. This assumption calls for local validation.

Long-Term Costs

The impact of long-term costs may be even more substantial than short-term costs because of surgical longevity. Caries, periodontitis, and noma typically require cycles of surgical treatment and retreatment.

In the case of filling for the treatment of dental caries, the standard of care—excavating potential carious lesions and placing undercuts to mechanically secure the fillings (Webster 1908)—undermines the long-term structural integrity of the tooth. Consequently, the "permanent" fillings have an average lifespan of about 10 years (Burke and Lucarotti 2009; Chadwick and others 2001; Downer and others 1999); the net result is the initiation of a rerestoration cycle. Estimates indicate that 70 percent of the replacement restorations are larger than the original fillings (Brantley and others 1995; Elderton 1990). With sequential restorations, the ultimate outcome in some cases is tooth loss and the need for bridges or implants. The attendant cost implications are significant (Shugars and Bader 1996). Therefore, in marked contrast to traditional thought regarding the efficacy of fillings (Mickenautsch and Yengopal 2012), complete caries removal is contraindicated for effective comprehensive prevention (Frencken and others 2012; Ricketts and others 2013).

The data for periodontitis and noma are less extensive but nonetheless informative. For periodontal health, current thinking recommends quarterly mechanical scaling. In marked contrast, clinical trials indicate that one round of a week-long regimen of metronidazole and amoxicillin shifts the oral ecology from disease related to health related, improves clinical health, and remains stable for up to five years without further intervention. For noma, the week-long costs for a regimen of metronidazole and amoxicillin and hyperalimentation are significantly less than extensive, repetitive, hospital-based surgeries. Further, with preventive care the patient is left with far fewer functional, esthetic, and emotional challenges.

In sum, the following approaches increase health care value:

- Effectively providing preventive services to people with diseases for which proven therapies exist
- Implementing integrated care delivery across multiple disease conditions
- Implementing local knowledge to ensure quality and equity.

Benefits of Focus on Prevention

The efficacy trials distilled in the multiple systematic reviews cited here indicate that prevention offers several theoretical and actual benefits:

- Moving oral health toward achieving health care's triple aim of increasing access, improving health, and reducing costs
- Facilitating the prevention and treatment of disease earlier in life and earlier in the disease progress, obviating the multitude of negative biological and social downstream consequences
- Improving health for both the well served and underserved, reducing one aspect of the social gradients.

The indicated benefits require vigorous testing in country- and region-specific effectiveness trials to demonstrate the universality of the findings (Banerjee and Duflo 2011; Glasgow and others 2005). These trials need to be supported by a noncommunicable disease system infrastructure to ensure care delivery across multiple systems.

Barriers and Challenges to Prevention Programs

Significant challenges to comprehensive prevention can be expected from governments, organizations, professional schools, clinicians, and regulatory agencies (Benzian and others 2011) (box 10.1). The reasons are relatively simple. First, these evidence-based, effective, preventive measures violate many of the oral health profession's closely held assumptions and clinical principles that focus on surgical treatment of dental diseases. Second, the current predominant stakeholders support an infrastructure, value system, and economy of training, licensing, boarding, and compensation that was created more than 100 years ago. This established social architecture will be difficult to change.

CONCLUSIONS

The challenge to achieving Alma-Ata's promise of "health care for all" (WHO 1978) and health care's triple aim will be to coordinate and integrate a top-down, noncommunicable disease policy change and a pragmatic bottom-up innovation approach (Christensen and others 2009; Frenk 2009). It seems unlikely that a top-down policy change will occur rapidly (Benzian and others 2011). It is much more likely that a bottom-up, pragmatic innovation approach to oral health care improvement will be successful in the short- and long-terms. Data-driven measures of bottom-up success will demonstrate the plausibility of and necessity for policy change.

Functionally, the challenge for pragmatic innovative programs will be to quantitatively improve health and document value, using methods of health improvement (IHI 2014; Langley and others 2009). Successful examples using local improvement initiatives with accompanying data are emerging (Banerjee and Duflo 2011; Monse and others 2013), but more are needed. Additionally, the incremental cost for delivering comprehensive prevention is likely to provide significantly greater benefit and value than incremental prevention. However, this economic assumption will require local validation. The effective preventive interventions identified in this chapter provide starting points.

If the multiple local and regional pilot oral health improvement initiatives simultaneously implement the multiple preventive interventions identified here, use community health workers to deliver care, and quantitatively assess outcomes and value, they are more likely to organically change policy and ensure sustainability than approaches that start with policy change. Finally, to effect this sea change, stakeholder advocates will need to consider actively providing evidence that is more easily understood by policy makers, specifically, advantage, simplicity, values, trust, and choice (Backer and Rogers 1998; Rogers 2002). These will be significant undertakings (Sheiham and others 2011; Williams 2011).

NOTES

The World Bank classifies countries according to four income groupings. Income is measured using gross national income (GNI) per capita, in U.S. dollars, converted from local currency using the *World Bank Atlas* method. Classifications as of July 2014 are as follows:

- Low-income countries (LICs) = US$1,045 or less in 2013
- Middle-income countries (MICs) are subdivided:
  - Lower-middle-income = US$1,046 to US$4,125
  - Upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more

1. Abdul Latif Jameel Poverty Action Lab (http://www.povertyactionlab.org/).
2. Abdul Latif Jameel Poverty Action Lab (http://www.povertyactionlab.org/health).
3. "2020 Topics and Objectives Oral Health." http://www.healthypeople.gov/2020/topicsobjectives2020/ebr.aspx?topicId=32.
4. "2020 Topics and Objectives Oral Health." http://www.healthypeople.gov/2020/topicsobjectives2020/ebr.aspx?topicId=32.

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