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PART FOUR

How Is Oral Health Promoted and Maintained and How Are Oral Diseases Prevented?

Safe and effective disease prevention measures for the common dental diseases exist and allow individuals, health care providers, and the community each to play a role, one that is enhanced by active partnerships among these groups. Unfortunately, not everyone has access to these measures. For example, some 40 percent of the U.S. population resides in communities that do not have optimal fluoride levels in their water supply.

Chapter 7 reviews the evidence for current prevention measures. Community water fluoridation remains an ideal public health measure, which benefits individuals of all ages and all socioeconomic strata. Other methods to deliver fluoride are reviewed, as is the use of dental sealants in caries prevention. The prevention of periodontal diseases and conditions such as oral and pharyngeal cancers and craniofacial injuries is at an early stage. Surveys of the knowledge and practices of the public and care providers reveal opportunities for enhanced education.

Attaining and maintaining oral health require a commitment to self-care and professional care. Chapter 8 highlights both individual responsibilities and emerging roles for health care providers. With greater understanding of the pathophysiology of oral diseases, providers can incorporate new preventive, diagnostic, and treatment strategies. These include developing risk assessment approaches for individual patients and adopting new strategies for the control of infections. Care providers are well positioned to instruct patients on tobacco cessation, appropriate dietary practices during pregnancy, and other healthful behaviors.

The professional provision of oral health care in America involves contributions from the dental, medical, and public health components. These are reviewed in Chapter 9, which focuses primarily on the dental component. A number of factors limit the capacity to improve the nation's oral health. Public assistance programs as currently designed are not meeting the oral health needs of eligible populations. A troubling lack of diversity exists in the oral health workforce, along with continued shortfalls in the number of men and women attracted to positions in oral health education and research. Correcting these limitations would contribute to increased access to care for underserved populations, enhanced preparation of future practitioners, and an expanded ability to pursue the many research questions generated in this report.

CHAPTER 7

Community and Other Approaches to Promote Oral Health and Prevent Oral Disease

The remarkable improvements in oral health over the past half century reflect the strong science base for prevention of oral diseases that has been developed and applied in the community, in clinical practice, and in the home. This chapter presents the evidence for key preventive measures for those oral conditions that pose the greatest burden to U.S. society. Because the emphasis given to each condition discussed here reflects the extent of the evidence for the associated preventive measures, the chapter is heavily weighted toward the prevention and control of dental caries, for which multiple effective preventive modalities have been developed.

The dental profession has long championed disease prevention and health promotion approaches to oral health. The initial observations in the 1930s that people living in communities served by naturally fluoridated water had lower dental caries inspired the trailblazing clinical prevention studies of the 1940s and 1950s. Researchers compared whole cities agreeing to fluoridate their water supplies to control cities whose drinking water contained only trace amounts of fluoride. Five years into the studies, follow-up with schoolchildren who had been examined at baseline revealed dramatic reductions in dental caries in the children drinking fluoridated water, as compared to controls. The overwhelming success of the studies led to a widespread adoption of community water fluoridation in the United States as a high-benefit, low-cost preventive method that benefited old and young, rich and poor alike. It also provided momentum for health practitioners, researchers, industry, and public health directors to consider other kinds of community-wide, provider-based, and individual strategies aimed at improving oral and general health.

Most common oral diseases can be prevented through a combination of community, professional, and individual strategies. The strategies selected here include disease prevention and health promotion interventions directed toward the public, practitioners, and policymakers to create a healthy environment, reduce risk factors, inform target groups, and improve knowledge and behaviors. They were selected on the basis of the significance of the health problem they were designed to prevent, whether in terms of prevalence, incidence, severity, cost, or impact on quality of life (see Chapters 4 and 6). Table 7.1 summarizes the strategies for the primary prevention of caries, periodontal diseases, oral and pharyngeal cancers, inherited disorders, and trauma, distinguishing among those that can be implemented community-wide, through health professionals, or through the exercise of individual responsibility. Some strategies can be applied at multiple levels. Box 7.1 provides a glossary of terms related to community health programs.

This chapter also includes a discussion of knowledge and practices of the public and health care providers regarding the three oral conditions about which we have the most knowledge. The purpose of this discussion is not to outline specific health promotion strategies to enhance knowledge and practices but to indicate the opportunities and needs for both broad-based and targeted health promotion programs and activities.

WEIGHING THE EVIDENCE THAT INTERVENTIONS WORK

Researchers, policymakers, and practitioners make judgments about whether a health intervention works based on estimates of its efficacy or effectiveness. Estimates of an intervention's efficacy are best based on randomized controlled trials, which may be conducted under ideal circumstances. Evidence for whether an intervention works when applied in the community at large is referred to as its effectiveness

(O'Mullane 1976). The distinction between efficacy and effectiveness is often blurred in dental public health programs because the studies and their settings can be very similar. Nevertheless, the major difference between the two lies in the degree of control exerted over factors that can affect results. Effectiveness studies more accurately reflect results that may be expected from the implementation of interventions.

The current trend in health care and public health is to base recommendations on evidence derived from systematic reviews of the literature and an assessment of the quality of evidence. The U.S. Preventive Services Task Force (1996) and the Canadian Task Force on the Periodic Health Examination (Ismail and Lewis 1993, Lewis and Ismail 1995) are examples of groups that have used systematic reviews to establish the evidence of efficacy or

TABLE 7.1
Community, provider, and individual strategies for primary prevention of key oral diseases and conditions

Community Strategies	Professional Strategies	Individual Strategies
Dental caries		
Community-wide health promotion interventions[a]	Counseling to follow measures to reduce risk of disease	Being informed about strategies to prevent disease
Fluoride use Community water fluoridation School-based dietary fluoride tablets School-based fluoride mouthrinse	Fluoride use Prescriptions for fluorides (supplements or rinses) Gels and other high-fluoride topicals Topical remineralization solutions Fluoride-containing restorative materials	Fluoride use Dentifrice Mouthrinse, over the counter
School-based and school-linked sealant programs	Provision of sealants Prescriptions for antimicrobial agents	Asking about sealants Use of antimicrobial agents
School-linked screening and referral	Individualized recall schedule	Self-initiated use of dental services
Periodontal diseases		
Community-wide health promotion interventions[a]	Counseling to follow measures to reduce risk of disease	Being informed about strategies to prevent disease
School-based personal hygiene, reinforcement of personal oral hygiene habits in Headstart or primary school classrooms	Control of plaque bacteria by mechanical means (prophylaxis or scaling) Chemical plaque control Chemotherapeutic agents	Oral hygiene measures Toothbrushing and flossing Toothbrushing with dentifrices Plaque control
School-linked screening and referral	Monitoring and early detection of disease	Self-initiated use of dental services
Oral and pharyngeal cancers		
Community-wide health promotion interventions[a]	Professional education and patient counseling on risk factors	Being informed about strategies to prevent disease Avoidance of tobacco use Reduction of alcohol use Use of sunscreen and lip protector
Cancer screening programs (such as health fairs)	Routine soft-tissue oral examination for early detection of precancerous lesions	Self-initiated use of dental services Request for cancer screening
Inherited disorders		
Early detection programs	Interdisciplinary early detection programs	
Trauma		
Community-wide health promotion interventions[a]	Professional education and patient counseling on risk factors	Being informed about strategies to prevent trauma
Mouth protector fittings for entire team	Fabrication of mouth protectors	Use of mouth protectors and helmets

[a]Community-wide health promotion interventions (education, political, regulatory, and organizational) are directed toward the public, practitioners, and policymakers to create a healthy environment, reduce risk factors, inform target groups, and improve knowledge and behaviors.

BOX 7.1
Glossary: The Nature of Community Health Programs

Community health programs are defined as health promotion and disease prevention activities that address health problems in populations. Community health programs often provide a level of organization and resources beyond those available to an individual. The programs thus complement personal care and professional services. Many programs target populations with limited access to professional services or limited resources to pay for services. Government agencies, religious organizations, charities, schools, foundations, and other private and public groups may spearhead such programs, tapping into the expertise, enthusiasm, and knowledge of community values of staff and volunteers. Some programs are sponsored by national, state, and local dental societies and their members.

Five terms related to community health programs—community, health promotion, health literacy, health education, and disease prevention—have been further articulated by experts in the field.

Community. According to Last (1995), a community is "a group of individuals organized into a unit, or manifesting some unifying trait or common interest." The unit can be a town, a geographic area, the state, nation, or body politic (Last 1995). The unit may also be a selected subgroup, such as disadvantaged children living in a large city or women urged to have mammograms according to specified schedules.

In designing and implementing community programs, planners must take into consideration that no two communities are identical. In a classic expression of this concept, McGavran (1979) wrote that a community is "an entity different from every other community as an individual is different from his neighbor: different in its physical makeup, its geographic and demographic limitation, different in its social structure, its power structure, its governmental and legal structure, different in mental and emotional patterns, in its ethnic groups, its mores, its religious and nutritional patterns, and different in its educational procedure, its institutions, and its community organization." On the other hand, communities may have similar risk factors for poor oral health, allowing common solutions to similar problems. Lessons learned in one community may be applicable to those with similar characteristics.

In recent years, investigators have begun to examine characteristics of communities, noting that some communities provide an environment that contributes to the overall health and well-being of the members, whereas others appear to be detrimental. All communities, however, have both positive and negative influences on health and well-being—the challenge is to minimize the negative factors and maximize the positive in each community. Healthy communities have been characterized as having a degree of openness and cooperation—neighbors helping neighbors. Healthy communities also are ones in which there are less extreme separations of individuals by social class (Wilkinson 1996).

Health Promotion. Health promotion is "any planned combination of education, political, regulatory, and organizational supports for action and conditions of living conducive to the health of individuals, groups, or communities" (Green and Kreuter 1999). Examples of broad-based health promotion activities include programs encouraging people of all ages to stop using tobacco, regulations requiring the use of mouthguards in contact sports, laws to prohibit tobacco sales to minors, and labels that indicate the amount of sugar in a product.

Health Literacy. Health literacy is "the capacity of individuals to obtain, interpret, and understand basic health information and services and the competence to use such information and services in ways which enhance health" (Joint Commission on National Health Education Standards 1995). Health literacy is correlated with general literacy, and both vary by educational achievement, socioeconomic status, race, and ethnicity. This is an important concern in a society that is becoming more diverse in terms of language, religion, culture, race, and ethnicity. Programs intending to serve, immigrants, for example, must attend to ensuring that information, programs, and systems are accessible, understandable, and culturally sensitive, particularly if the target audience for health information and services does not speak English, if there are unique cultural and religious beliefs at variance with those of the dominant culture, or if living arrangements are such that individuals lack access to sources of health information and care.

Health Education. Health education is an important part of health promotion. It is defined as "any planned combination of learning experiences designed to predispose, enable, and reinforce voluntary behavior conducive to health in individuals, groups, or communities" (Green and Kreuter 1999). Examples include the multiple campaigns to prevent tobacco use among youth. An example at the statewide level is Arizona's promotion of the use of dental sealants with an educational campaign that says "Sealants Are in the Groove."

Disease Prevention. The term *prevention* embodies the goal of promoting and preserving health and minimizing suffering and distress. Community health programs generally focus on either *primary* prevention—removing or reducing risks or providing protection from disease before it occurs—or *secondary* prevention—screening and early detection and intervention to arrest the progress of disease after it occurs. *Tertiary* prevention—rehabilitating and restoring structure and function—is provided in some community-based programs, such as clinical dental care organized and delivered under conditions determined by the community.

effectiveness of clinical preventive services for the purpose of making recommendations. Similar reviews of the evidence of effectiveness for community preventive services are currently under way by the Task Force on Community Preventive Services (2000). These reports provide clear statements about the evidence and recommendations for or against a given strategy.

The discussion in this chapter is more illustrative than comprehensive. Readers are encouraged to seek specific guidance from the reports of the U.S. Preventive Services Task Force where available. Furthermore, because of the interest in community preventive services, "expert opinion" about the merits of community interventions is included, even though the work of the Task Force on Community Preventive Services has not been completed. Expert opinion is formed by less systematic reviews of the literature or addresses interventions to be applied in settings other than those previously studied.

In particular, suggestions are offered for several interventions intended to reduce oral disease and promote oral health that reflect the opinion of experts who contributed to this report. Until findings from additional research are available, expert opinion remains the best guidance for community interventions where only efficacy studies have been done or where they were applied to populations with different attributes or risk factors than those of current interest. Also, expert opinion has been used where there is an interest in criteria that were not considered in previous efficacy studies, such as cost-effectiveness and practicality.

Readers interested in more detailed information about interventions in areas such as control of tobacco use or motor vehicle safety are directed to the upcoming report of the Task Force on Community Preventive Services (2000).

Interventions included in this chapter (and highlighted in Table 7.1) are those that have been shown to be effective in certain settings, but which can be applied in other settings. The anticipated benefits may be difficult to determine. In general, the per capita cost of an intervention is lower for community interventions and is usually a function of the number of people reached for a given level of professional effort. Effectiveness, however, is often a function of the risk characteristics of a given individual in the group receiving the intervention. Such risk factors are often easier to target by individual practitioners than by community programs. In the absence of contemporary data, the promotion of strategies deemed to be more cost-effective than others relies on the opinion of experts. Individual decision making regarding self- or provider care further reflects the subjective value placed on the outcome of care. Therefore, it is not possible to make general statements about the superiority of any given approach.

PREVENTION AND CONTROL OF DENTAL CARIES

Although many caries prevention strategies, notably community water fluoridation and use of a fluoride-containing dentifrice, benefit adults and children alike, most of our understanding of the effectiveness of these strategies comes from the study of children, during a life stage when caries incidence is high. Caries prevention programs have been designed and evaluated for children and have used a variety of fluoride and dental sealant strategies applied separately and together. Because these strategies are complementary, their use in combination has the potential of virtually eliminating dental caries in all children. However, dental caries is a problem for all ages. Although direct evidence of caries preventive strategies in adults is limited, the evidence that does exist is consistent with expected effects based on experience with children. The Centers for Disease Control and Prevention (CDC) recently convened an expert work group to develop recommendations for modalities to prevent and control dental caries based on a review of publications selected by the work group and other experts. The resulting recommendations are summarized in Table 7.2, where they are organized according to quality of evidence, strength of recommendation, and target population in accordance with criteria adapted from the U.S. Preventive Services Task Force (CDC in press).

Fluoride

Fluoride reduces the incidence of dental caries and slows or reverses the progression of existing lesions (i.e., helps prevent cavities). Today, all Americans are exposed to fluoride to some degree, and there is little doubt that widespread use of fluoride has been a major factor in the overall decline in recent decades in the prevalence and severity of dental caries in the United States and other economically developed countries (Bratthall et al. 1996).

Fluoride is the ionic form of the element fluorine, the thirteenth most abundant element in the crust of the Earth. Because of its high affinity for calcium, fluoride is mainly associated with calcified tissues (i.e., bones and teeth). The ability of fluoride to inhibit, and even reverse, the initiation and progression of dental caries is well known. Fluoride's mech-

anisms of action include incorporation of fluoride into enamel preeruptively, inhibition of demineralization, enhancement of remineralization, and inhibition of bacterial activity in dental plaque.

A variety of theories regarding fluoride's mechanisms of action account for the range of fluoride products available (Burt and Eklund 1999, Stookey and Beiswanger 1995). The initial theory of action was based on the belief that incorporation of fluoride into the hydroxyapatite of developing tooth enamel in the preeruptive phase reduced the mineral's solubility, thereby increasing enamel resistance. Because of the length of time the tooth is at risk of caries during the posteruptive phase, however, the topical effects of fluoride are considered to predominate (Clarkson et al. 1996). These effects are based on fluoride's role in the aqueous phase around the tooth, both in saliva and in dental biofilm (plaque). Fluoride in plaque contributes to the remineralization of demineralized enamel when bound fluoride is released during an acid challenge, resulting in a more acid-resistant enamel surface structure. Fluoride also has been shown to inhibit the process of glycolysis by which fermentable carbohydrates are metabolized by cariogenic bacteria to produce acid. All these effects occur after the tooth erupts, while it is functioning in the mouth, enabling fluoride to prevent caries over a lifetime in both children and adults.

The first use of fluoride for caries prevention was in 1945 in the United States and Canada, when the fluoride concentration was adjusted in the drinking water supplying four communities (Arnold et al. 1962, Ast and Fitzgerald 1962, Blayney and Hill 1967, Hutton et al. 1956). This public health approach followed a long period of epidemiologic studies of the effects of naturally occurring fluoride in drinking water (Burt and Eklund 1999).

The success of the community water fluoridation trials in reducing dental caries led to the development of other important fluoride-containing products, such as dietary supplements and, most notably, fluoride-containing dentifrices, in the early 1960s. Fluoride-containing gels, solutions, pastes, and varnishes were also developed for topical use, either applied by professionals or self-applied at home or in other settings. All of these products were tested for safety and effectiveness in reducing caries. Products designed for professional use generally have higher concentrations and are used at less frequent intervals than those designed for self-application.

Controlled clinical trials from the 1940s through the 1970s documented the benefits of professionally applied fluoride in reducing dental caries, and several excellent reviews are available (Horowitz and Ismail 1996, Johnston 1994, Ripa 1990, Stookey and Beiswanger 1995). Professional application of fluoride is inherently more expensive than self-applied methods, so the use of such an approach for groups and individuals at low risk of dental caries is unlikely to be cost-effective. For patients at high risk of dental caries, however, professionally applied fluoride is still considered cost-effective. It is not clear whether fluoride varnishes and

TABLE 7.2
Quality of evidence, strength of recommendation, and target population of recommendation for each modality to prevent and control dental caries

Modality[a]	Quality of Evidence (grade)	Strength of Recommendation (code)	Target Population[b]
Community water fluoridation	II-1	A	All areas
School water fluoridation	II-3	C	Rural, nonfluoridated areas
Fluoridated dentifrices	I	A	All persons
Fluoride mouthrinses	I	A	High risk[c]
Fluoride supplements			
Pregnant women	I	E	None
Children aged <6 years	II-3	C	High risk
Children aged 6 to 16 years	I	A	High risk
Persons aged >16 years	N.A.	C	High risk
Fluoride gels	I	A	High risk
Fluoride varnishes	I	A	High risk
Dental sealants	I	A	High risk[d]

Notes: Criteria for quality of evidence and strength of recommendation designations are adapted from USPSTF as Table 5.3.

N.A. = no published studies of effectiveness of fluoride supplements in controlling dental caries among persons aged >16 years.

[a] Assume that the modalities are used as directed in terms of dosage and age of user.

[b] The quality of evidence for targeting some modalities to persons at high risk is grade III, representing the opinion of respected experts, and is based on considerations of cost-effectiveness that were not included in the studies establishing efficacy or effectiveness.

[c] Groups believed to be at high risk for caries are members of families of low socioeconomic status (SES) or with low levels of parental education; those seeking dental care on an irregular basis; and persons without dental insurance or access to dental service. Individual factors contributing to increased risk are currently active dental caries; a history of high caries experience in older siblings or caregivers; exposed root surfaces; high levels of infection with cariogenic bacteria; impaired ability to maintain oral hygiene; reduced salivary flow due to medications, radiation treatment, or disease; and the wearing of orthodontic appliances or prostheses.

[d] Assessment of risk is based on both patient and tooth-specific factors.

Source: Modified from CDC in press, and ASTDD 1995.

gels would be most efficiently used in clinical programs targeting groups at high risk of dental caries or whether they should be reserved for individual high-risk patients.

The U.S. Preventive Services Task Force (Greene et al. 1989, USPSTF 1996) and the Canadian Task Force on Periodic Health Examination (Lewis and Ismail 1995) affirm that there is strong evidence to support the major methods for providing fluoride to prevent dental caries.

The safety of fluoride is well documented and has been reviewed comprehensively by several scientific and public health organizations (Institute of Medicine (IOM) 1997, National Research Council (NRC) 1993, Newbrun 1996, U.S. Department of Health and Human Services (USDHHS) 1991, World Health Organization (WHO) 1984). When used appropriately, fluoride has been demonstrated to be both safe and effective in preventing and controlling dental caries. The IOM (1997) classified fluoride as a micronutrient, citing it, along with calcium, phosphorus, magnesium, and vitamin D, as an important constituent in maintaining health.

Appropriate use of fluoride products can minimize the potential for enamel fluorosis, a broad term applied to certain visually detectable changes in the opacity of tooth enamel associated with areas of fluoride-related developmental hypomineralization. There are also many developmental changes in enamel that are not fluoride-related (Fejerskov et al. 1990). Most enamel fluorosis seen today is of the mildest form, which affects neither aesthetics nor dental function. Cosmetically objectionable enamel fluorosis can occur when young children ingest higher than optimal amounts of fluoride, from any source, while tooth enamel is forming (up to age 6). Its occurrence appears to be most strongly associated with the total cumulative fluoride intake during the period of enamel development, but the condition's severity depends on the dose, duration, and timing of fluoride intake. Specific recommendations have been made to control fluoride intake by children during the years of tooth development (USDHHS 1991).

Fluoridation of Drinking Water

For more than half a century, community water fluoridation has been the cornerstone of caries prevention in the United States; indeed, CDC has recognized water fluoridation as one of the great public health achievements of the twentieth century (CDC 1999). All water contains at least trace amounts of fluoride. Water fluoridation is the controlled addition of a fluoride compound to a public water supply to achieve a concentration optimal for dental caries prevention. In the 1940s, Dean et al. (1941) concluded that 1 ppm (part per million) fluoride was the optimal concentration for climates similar to that of the Chicago area; this concentration would significantly reduce the prevalence of dental caries with an acceptably low prevalence of enamel fluorosis. Current U.S. Public Health Service (USPHS) recommendations for fluoride use include an optimally adjusted concentration of fluoride in drinking water ranging from 0.7 to 1.2 ppm, depending on the mean maximum daily air temperature of the area (Galagan and Vermillion 1957, USDHEW 1962). A lower fluoride concentration is recommended for communities in warmer climates than cooler climates, because it is assumed that persons living in warmer climates drink more tap water.

Effectiveness

Numerous studies in naturally fluoridated areas preceded the field trials. There are no randomized, double-blind, controlled trials of water fluoridation because its community-wide nature does not permit randomization of people to study and control groups. Similar results have been derived from numerous well-conducted field studies by various investigators on thousands of subjects in different parts of the world. Conducting a study in which individuals are randomized to receive or not receive fluoridated water is unnecessary and is not feasible.

In 1945, Grand Rapids, Michigan, became the first city in the United States to fluoridate its water supply; the oral health of its schoolchildren was periodically compared with that of schoolchildren in the control city, Muskegon, Michigan. Dramatic declines in dental caries among children in Grand Rapids and three other cities conducting studies shortly thereafter led to fluoridation in many other cities. In an extensive review of 95 studies conducted between 1945 and 1978, Murray et al. (1991) reported the modal caries reduction following water fluoridation to be between 40 and 50 percent for primary teeth and 50 and 60 percent for permanent teeth. Newbrun (1989) reported on more than 60 studies conducted during the 1970s and early 1980s, limiting his review to those with concurrent control groups because of the continuing decline in dental caries in both fluoridated and nonfluoridated areas. Comparisons of fluoride-deficient and fluoridated communities in the United States, Australia, Britain, Canada, Ireland, and New Zealand have consistently demonstrated the

continued effectiveness of water fluoridation. Caries reductions ranged between 15 and 40 percent in fluoridated, as compared with fluoride-deficient, communities (USDHHS 1991).

Fluoridation also benefits middle-aged and older adults. Benefits to adults include reductions in both coronal and root caries. These benefits are important because older people typically experience gingival recession, which results in exposed root surfaces, which are susceptible to caries. In addition, tooth retention in older U.S. cohorts has increased in recent decades, so that the number of teeth at risk for caries in older age groups is also increasing. Finally, many medications used to treat chronic diseases common in aging have the side effect of diminished salivary flow, depriving teeth of the many protective factors in saliva.

Other evidence of the benefits of fluoridation comes from studies of populations where fluoridation has ceased. Examples in the United States, Germany, and Scotland have shown that when fluoridation is withdrawn and there are few other fluoride exposures, the prevalence of caries increases. In Wick, Scotland, which began water fluoridation in 1969 but stopped it in 1979, the caries prevalence in 5- to 6-year-olds with limited exposure to other sources of fluoride increased by 27 percent between 1979 and 1984. This was despite a national decline in caries and increased availability of fluoride-containing dentifrices (Kugel and Fischer 1997, Seppä et al. 1998, Stephen et al. 1987).

Costs and Cost-effectiveness

The increase in other fluoride exposures since water fluoridation was first introduced in 1945—particularly from fluoride-containing dentifrices, mouthrinses, and foods and beverages processed using fluoridated water—has led to smaller differences in the prevalence of dental caries between people in fluoridated and those in nonfluoridated communities than in the past. Most public health experts believe that water fluoridation continues to be a highly cost-effective strategy, even in areas where the overall caries level has declined and the cost of implementing water fluoridation has increased (Burt 1989, CDC 1999).

Compared to the cost of restorative treatment, water fluoridation actually provides cost savings, a rare characteristic for community-based disease prevention strategies (Garcia 1989). The mean annual per capita cost of fluoridation ranges from $0.68 for systems serving populations greater than 50,000 (large systems) and $0.98 for systems serving between 10,000 and 50,000 (medium systems), to $3.00 for systems serving less than 10,000 (small systems) (reported in 1999 dollars) (Ringelberg et al. 1992). In 1992, approximately 60 percent of the U.S. population receiving fluoridated water was served by large systems, 31 percent by medium systems, and 9 percent by small systems (USDHHS 1993).

Access to Optimally Fluoridated Water in the United States

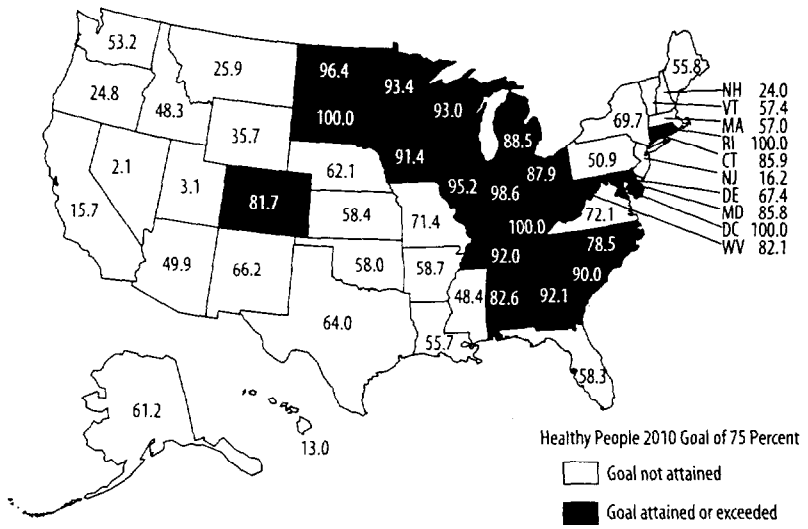
The most recent national data on the extent of community water fluoridation reflect the status of fluoridation in 1992 (see Figure 7.1 and Table 7.3). About 145 million people, or 62 percent of the population served by public water supplies, consume water with optimal fluoride levels. Of the 50 largest cities in the United States, 43 are fluoridated (Table 7.4). Residents of the seven unfluoridated cities in the group are among the almost 100 million persons in the United States who lack this method of caries prevention.

Although many states and large cities had been quick to implement fluoridation programs in the 1950s and 1960s, the trend then began to level off. In the absence of legislative mandates in most states and categorical federal funding, fluoridation decisions are left to the states, and frequently to local governments and city councils. Thus expansion of fluoridation in the United States is not simple and requires decisions at many levels. The national health promotion and disease prevention objectives in Healthy People 2010 (USDHHS 2000) call for increasing the percentage of Americans on public water supplies drinking fluoridated water from 62 to 75 percent—a 21 percent improvement (see Figure 7.1). This would mean adding 30 million people served by well over 1,000 community water systems to those who currently have access to fluoridated public water systems (USDHHS 1993).

Summary: Community Water Fluoridation

Epidemiological studies carried out during the last five decades provide strong evidence supporting the effectiveness of water fluoridation in preventing coronal and root caries in children and adults. Further support of effectiveness comes from studies that indicate that caries experience increases in communities that no longer fluoridate the water supply (and where there are few other exposures to fluorides). Given the modest cost of less than 1 dollar per person per year to fluoridate water systems serving most people, community water fluoridation is recommended as a very effective and cost-effective

FIGURE 7.1
Percentage of U.S. population by state served by fluoridated public water supply, 1992



Source: USDHHS 1993.

TABLE 7.3
Population served by fluoride-adjusted and naturally fluoridated water, United States, 1992

Type of Fluoridation	Population	Number of Systems	Number of Communities
Adjusted	134.6 million	10,567	8,572
Natural	10.0 million	3,784	1,924
Both	144.6 million	14,351	10,496

Source: USDHHS 1993.

method of preventing coronal and root caries in children and adults. Moreover, water fluoridation benefits all residents served by community water supplies regardless of socioeconomic status. Few barriers to its implementation exist, with the important exception of the political opposition that the measure often engenders and certain technical difficulties and costs involved in fluoridating very small water systems.

School Water Fluoridation

During the 1960s, 1970s, and 1980s, programs were initiated to bring the benefits of fluoride in drinking water to children living in homes supplied by well water and whose schools had independent water supplies. The idea was to adjust the fluoride content of the water supplies of the schools these children attended, especially consolidated rural schools, to levels higher than those that would be used for community water fluoridation, taking into account that the children were present for only portions of the day and year.

Although the strategy shares some of the advantages of community water fluoridation—serving rich and poor alike and requiring no action on the part of the children (other than drinking the water)—a number of disadvantages were evident from the outset. These included the limitations inherent in beginning exposure to fluoride only when children were of school age and then providing only intermittent exposure. Also, the possibility that the exposure would not confer benefits after the children left school was a concern. Practical considerations included the cost of operations, personnel, logistical difficulties, and mandatory water testing (CDC 1995). Moreover, the intervening decades have seen increased school consolidations, increased coverage of schools by community-wide water systems, declining numbers of children who could benefit from such programs, and a continuing general decline in dental caries in children. Another concern is that schools increasingly enroll preschoolers into daycare programs for which school water fluoridation at higher levels than for community water systems is not appropriate. Only four intervention studies evaluating the effectiveness of school water fluoridation have been published.

Summary: School Water Fluoridation

Given the limitations of the evidence for effectiveness, as well as the difficulties of implementation and operation, school water fluoridation has limited application. Decisions to initiate or continue school fluoridation programs should be based on an assessment of present caries risk in the target school(s), alternative preventive modalities that may be available, and periodic evaluation of program effectiveness.

Dietary Fluoride Supplements

Dietary fluoride supplements are available as tablets that are swallowed or chewed, drops that are swallowed, and lozenges that dissolve slowly in the

mouth. They can provide topical and systemic fluoride for children in the absence of optimally fluoridated drinking water. In the United States, supplements are available by prescription only, to be used once a day beginning at 6 months and ending at age 16. According to a 1986 National Health Interview Survey (NHIS), slightly more than 16 percent of children younger than 2 years used fluoride dietary supplements (Nourjah et al. 1994).

The fluoride supplement dosage schedule in use in the United States was last revised by the American Dental Association (ADA) in 1994 (Table 7.5) (ADA 1995). This schedule, based on the level of fluoride in the community water supply and on the age of the child, has also been endorsed by the American Academy of Pediatric Dentistry and the American Academy of Pediatrics. Fluoride supplements should not be prescribed for individuals living in optimally fluoridated communities.

Effectiveness of Home Use

The current fluoride supplement dosage schedule does not recommend prescribing fluoride for infants younger than 6 months. A double-blind study of fluoride supplements conducted to ascertain the effects of fluoride administered to the mother during the last 6 months of pregnancy followed by 5 years of supplements to the child after birth found no additional benefits from prenatal fluoride use (Leverett et al. 1997). In a randomized, double-blind, controlled trial in which supplements were administered from birth, Hennon et al. (1967) had found statistically significant 4-year reductions in caries in primary and permanent teeth of 65 and 41 percent, respectively. Beyond this study, which was conducted when other sources

TABLE 7.4
Water fluoridation status of top 50 U.S. cities

	Population Estimate (7/1/96)	Size Rank 1996	Fluoride/ No Fluoride[a]
New York, New York	7,380,906	1	F
Los Angeles, California	3,553,638	2	F
Chicago, Illinois	2,721,547	3	F
Houston, Texas	1,744,058	4	F
Philadelphia, Pennsylvania	1,478,002	5	F
San Diego, California[b]	1,171,121	6	NF
Phoenix, Arizona	1,159,014	7	F
San Antonio, Texas	1,067,816	8	NF
Dallas, Texas	1,053,292	9	F
Detroit, Michigan	1,000,272	10	F
San Jose, California	838,744	11	NF
Indianapolis, Indiana	746,737	12	F
San Francisco, California	735,315	13	F
Jacksonville, Florida	679,792	14	F-nat
Baltimore, Maryland	675,401	15	F
Columbus, Ohio	657,053	16	F
El Paso, Texas	599,865	17	F-nat
Memphis, Tennessee	596,725	18	F
Milwaukee, Wisconsin	590,503	19	F
Boston, Massachusetts	558,394	20	F
Washington, D.C.	543,213	21	F
Austin, Texas	541,278	22	F
Seattle, Washington	524,704	23	F
Nashville-Davidson (remainder), Tennessee	511,263	24	F
Cleveland, Ohio	498,246	25	F
Denver, Colorado	497,840	26	F
Portland, Oregon	480,824	27	NF
Fort Worth, Texas	479,716	28	F
New Orleans, Louisiana	476,625	29	F
Oklahoma City, Oklahoma	469,852	30	F
Tucson, Arizona[b]	449,002	31	NF
Charlotte, North Carolina	441,297	32	F
Kansas City, Missouri	441,259	33	F
Virginia Beach, Virginia	430,385	34	F
Honolulu, Hawaii	423,475	35	NF
Long Beach, California	421,904	36	F
Albuquerque, New Mexico	419,681	37	F
Atlanta, Georgia	401,907	38	F
Fresno, California	396,011	39	NF
Tulsa, Oklahoma	378,491	40	F
Las Vegas, Nevada	376,906	41	F
Sacramento, California	376,243	42	F
Oakland, California	367,230	43	F
Miami, Florida	365,127	44	F
Omaha, Nebraska	364,253	45	F
Minneapolis, Minnesota	358,785	46	F
St. Louis, Missouri	351,565	47	F
Pittsburgh, Pennsylvania	350,363	48	F
Cincinnati, Ohio	345,818	49	F
Colorado Springs, Colorado	345,127	50	F

[a] F = fluoride, NF = no fluoride, and F-nat = natural, nonadjusted fluoride in the water supply.
[b] Voted but not yet started.
Source: T. Reeves, CDC Division of Oral Health, personal communication, April 18, 2000.

of fluoride were not as widespread as today, there are no well-designed clinical trials of home-based administration of postnatal supplements. As Murray and Naylor (1996) noted, many studies are difficult to interpret, either because of small size, short experimental period, or inadequate reporting. The studies are further complicated by problems in self-selection bias, in choosing comparable control groups, and in compliance to the daily regimen.

Notwithstanding the paucity of true randomized controlled clinical trials to demonstrate efficacy of supplement use in children, at least 60 studies have reported on the effectiveness of fluoride tablets or drops in home- or school-based programs (Driscoll 1974, Murray and Naylor 1996, Stephen 1993). However, none used the current prescribing schedule. Altogether, the evidence for using fluoride supplements to prevent and control dental caries is mixed. Although many studies have reported that the use of fluoride supplements by infants and children before their permanent teeth erupt reduces caries in permanent teeth, many other studies have reported that it does not (CDC in press). For children aged 6 to 16 who take supplements after most teeth have erupted, the evidence is much clearer that fluoride reduces caries experience (DePaola and Lax 1968, Driscoll et al. 1978, Stephen and Campbell 1978).

Most of the supplements taken at home are prescribed by physicians and dentists in private practice, with physicians prescribing the larger share. Two difficulties are associated with home use. First, the provider may prescribe incorrectly; second, compliance with home-based tablet programs can be very poor. More public and professional education is needed to overcome the difficulties inherent in following recommended regimens for home use of fluoride supplements, which require motivation and adherence on the part of children, parents, and prescribers.

Effectiveness of School-based Programs

Most community fluoride supplement programs are school-based. Each school day, participating students receive a tablet, which they chew under supervision, swishing the resultant solution between the teeth for 30 seconds before swallowing.

Supplement programs in schools have been shown to be effective in preventing caries in permanent teeth when administration is tightly controlled and children are instructed to let the tablet dissolve slowly, to ensure as much topical fluoride exposure as possible. Under these conditions, randomized controlled trials in the United States reported caries reductions of 20 to 28 percent over periods of 3 to 6 years (DePaola and Lax 1968, Driscoll et al. 1978). In a randomized, double-blind, 3-year study of Scottish schoolchildren who were 5.5 years of age at the start of the study, a much higher percentage reduction in caries in permanent teeth was observed (Stephen and Campbell 1978). In this study, teachers were specifically requested to encourage children each school day to let the sodium fluoride tablet dissolve slowly. These children were from lower socioeconomic groups and may not have had access to fluoride-containing dentifrices and other sources of fluoride, factors that most likely put them at high risk for caries.

Costs of School-based Programs

The costs of a school-based tablet program are low because equipment is not necessary, the procedure does not take long, and an entire classroom of children can participate at once. A 1988 survey of five programs ranging from 7 to 49 schools and 657 to 10,751 children found an average direct cost of approximately $2.53 per child per school year (Garcia 1989). The costs ranged from $0.81 to $5.40, depending on whether paid personnel or volunteers supervised the procedure. The economic benefits of a fluoride supplement program were assessed in randomized controlled clinical trials in Manchester, England, and results showed overall health and cost benefits for the experimental group (O'Rourke et al. 1988).

Summary: Dietary Fluoride Supplements

For children not exposed to optimal fluoride concentration in their water supply, the evidence from studies conducted prior to the 1980s supporting the effectiveness of home use of daily dietary fluoride supplements in preventing dental caries in school-aged children is weak. However, the evidence of the effectiveness of school-based fluoride supplement programs is strong. Such programs require highly

TABLE 7.5
Dietary fluoride supplement dosage schedule

Age of Child	Fluoride Dosage (milligrams per day) at Fluoride in Water Concentration of		
	<0.3 ppm	0.3 to 0.6 ppm	>0.6 ppm
Birth to 6 months	None	None	None
6 months to 3 years	0.25	None	None
3 years to 6 years	0.50	0.25	None
6 years to 16 years	1.00	0.50	None

Source: ADA 1995.

motivated teachers and students, a requirement that likely has limited their widespread adoption. Experts recommend that school-based dietary fluoride supplement programs are likely to be effective in providing topical fluoride protection for children at high risk for dental caries in settings where supervising personnel are highly motivated (CDC in press, Clarkson 1992, Ismail 1994, WHO 1994). Under these conditions, such programs may also be cost-effective.

Fluoride Mouthrinses

Several different formulations of fluoride mouthrinses are available, differing in the amount of fluoride and suggested frequency of use. Rinses with low fluoride concentrations (0.05 percent neutral sodium fluoride or 0.1 percent stannous fluoride) are designed for daily use and are available over-the-counter. Higher-concentration rinses (0.2 percent sodium fluoride) are designed for weekly use and are available only by prescription or in public programs.

School-based Programs

Fluoride mouthrinses were developed in the 1960s as a public health measure for use primarily in schools. They were conceived as a way of avoiding the high costs associated with professional applications of gels and other topical fluoride products in school settings and the poor acceptance by children of brush-on fluoride pastes.

For children in the first grade and up, the procedure consists of vigorously rinsing with 10 milliliters (ml) of solution for 60 seconds. After the rinsing, the fluoride solution is expectorated into a cup, a napkin is inserted to absorb the solution, and both are disposed. Kindergarten children rinse with only 5 ml of solution.

Effectiveness

School-based fluoride mouthrinse programs have been evaluated extensively during the past three decades and have been the subject of numerous reviews (Adair 1998, Birkland and Torell 1978, Bohannan et al. 1985, Petersson 1993, Ripa 1991, Stamm et al. 1984, Torell and Ericsson 1974). Of the many studies during the 1970s and 1980s, 13 satisfied the strict criteria of randomized controlled clinical trials. Caries reductions ranging from 20 to 50 percent were observed, firmly establishing their efficacy. No recent controlled trials have been done. After the efficacy of fluoride mouthrinses was established, a 17-site national school-based demonstration program showed that a protocol involving weekly rinsing with 0.2 percent sodium fluoride was eminently practical. Most studies done after efficacy was established used a before-and-after design with no concurrent comparison group. This design might overestimate the caries reduction effects. On the whole, however, the programs appear to have been effective.

A survey conducted in 1984 found fluoride mouthrinsing programs in 48 states, with 3.2 million children participating (Bednarsh and Connolly 1984). A later study by CDC reported that 3.25 million schoolchildren were participating in mouthrinsing programs at 11,683 sites in 1988 (Burt 1989), although there are reports that some states have recently curtailed use of these programs (R. Kuthy, personal communication, 2000).

Cost-effectiveness

The cost of the procedure in 1988 ranged between $0.52 and $1.78 per child per school year, depending on whether paid or volunteer adult supervisors were used (Garcia 1989). An extensive study during the late 1970s, when downward trends of caries rates were noted, questioned the cost-effectiveness of rinse programs (Klein et al. 1985). Fluoride mouthrinses may be more cost-effective when targeted to schoolchildren with high caries activity (Bawden et al. 1980, Leverett 1989, Torell and Ericsson 1965).

Summary: School-based Fluoride Mouthrinse Programs

Sufficient evidence exists from studies conducted before 1985 to support the effectiveness of 0.2 percent sodium fluoride mouthrinses in preventing coronal caries in school populations. There is evidence that with a declining prevalence of dental caries, the cost-effectiveness of these procedures is reduced. Experts recommend that school-based rinsing once a week with 0.2 percent sodium fluoride is likely to be effective if used in schools and classrooms where students are at high risk for caries and if applied consistently over time (CDC in press). Fluoride mouthrinse programs are not recommended for preschool children in the United States, and programs for kindergarten children should use only 5 ml of solution.

Fluoride Varnishes

Fluoride varnishes have not been approved for use in the United States with an anticaries indication. However, the U.S. public health community has begun to investigate the use of fluoride varnishes,

which became available in this country in 1994. The varnishes are viscous, resinous lacquers painted onto teeth. Because the varnish adheres to enamel surfaces for up to 12 hours or more, fluoride retention in the mouth is greater than with solutions or gels. Varnishes have been used in Europe for 30 years.

No data are available on the use of varnishes in children under 3 years, and, although the results were positive, only two randomized clinical trials have been conducted abroad using preschoolers (Holm 1979, Peyron et al. 1992). Many fluoride rinsing programs in Finland have been replaced with fluoride varnish application programs (Seppä 1991, Sundberg et al. 1996). Studies conducted in Canada (Clark et al. 1987) and Europe (de Bruyn and Arends 1987, Helfenstein and Steiner 1994, Twetman et al. 1996) have found that fluoride varnish is efficacious in preventing dental caries. Applied semiannually, this modality is as effective as professionally applied fluoride gel (Seppä et al. 1995). Some researchers advocate application of fluoride varnish up to 4 times per year to achieve maximum effect, but the evidence of benefits from more than two applications per year remains inconclusive (Mandel 1994, Seppä 1991, Seppä and Tolonen 1990). Other studies have shown that three applications in 1 week, once a year, may be more effective than the more conventional biannual regimen (Petersson et al. 1991, Skold et al. 1994). European studies have shown that fluoride varnishes prevent decalcification (a very early stage of dental caries) beneath orthodontic bands (Adriaens et al. 1990) and slow the progression of existing enamel lesions (Peyron et al. 1992). Findings on cost-effectiveness are mixed (Kirkegaard et al. 1986, Koch et al. 1979, Seppä and Pollanen 1987, Vehmanen 1993).

Dental Sealants

The pits and fissures that characterize the biting surfaces of posterior teeth provide a haven for food debris and decay-causing bacteria. Not surprisingly, these sites are often the first and most frequent to be affected by decay in children and adolescents. The width of most pits and fissures is narrower than a single toothbrush bristle, making cleaning of their deepest recesses almost impossible. According to national estimates, as much as 90 percent of all dental caries in schoolchildren occurs in pits and fissures (Kaste et al. 1996). The teeth at highest risk by far are permanent first and second molars.

Enamel bonding, a technology introduced in the mid-1950s, led to the development of sealants. These are clear or opaque plastic resinous materials designed for professional application to the pit-and-fissure surfaces of teeth. The material hardens within 60 seconds or so into a thin, hard, protective coating. Sealants were introduced in the late 1960s and received the American Dental Association Seal of Approval in 1976 (ADA 1976). Most of the dozen products approved by the ADA do not contain a therapeutic agent, but work by providing a physical barrier that prevents microorganisms and food particles from collecting in the pits and fissures (ADA 1997). First-generation sealants used ultraviolet light to harden or "cure" the material; improved second- and third-generation sealants cure by chemical or visible light activation, respectively.

Sealant placement requires meticulous attention to technique, but they can be successfully provided in "field" settings using portable dental equipment. To be most effective, sealants should be placed on teeth soon after they erupt, but they can be applied across a wide age range. Not only does the risk for caries continue across the life span, but an individual's risk can increase for any number of reasons. Sealants are particularly helpful for persons with medical conditions associated with higher caries rates, children who have experienced extensive caries in their primary teeth, and children who already have incipient caries in a permanent molar tooth.

Efficacy

Initial clinical trials using a random half-mouth design and first- or second-generation sealant materials established their efficacy. Several comprehensive reviews and a meta-analysis of the amount of caries prevented testify to the utility of these materials (Llodra et al. 1993, Ripa 1993, Weintraub 1989). Llodra et al. (1993) used a systematic process to select and review studies of one-time sealant placement on permanent teeth in subjects unexposed to other preventive measures. Pooled results from 17 studies meeting their selection criteria found that second-generation sealants reduced caries over 70 percent.

These early trials firmly established retention as essential to preventing caries; a sealant is virtually 100 percent effective if it is fully retained on the tooth (NIH 1984). Mertz-Fairhurst (1984) reported 92 to 96 percent retention rates in second-generation sealants after 1 year, with 67 to 82 percent retention after 5 years. A review of studies of long-term retention of second-generation sealants showed 41 to 57 percent intact after 10 years (Ripa 1993). The longest-running study of a one-time application of a first-generation sealant indicated a reduction in pit-and-fissure caries by 52 percent after 15 years

Simonsen 1991). Retention results for third-generation sealants are similar to those for second-generation systems (Ripa 1993).

Effectiveness

Administrators of school-linked sealant programs (Collins et al. 1985, Sterritt and Frew 1988) and of school-based programs with either fixed clinics (Ismail et al. 1989, Messer et al. 1997, Whyte et al. 1987) or portable equipment (Bravo et al. 1996, Calderone and Davis 1987, Calderone and Mueller 1983, Hardison 1983, Kumar et al. 1997, Morgan et al. 1998) have reported on their experiences with these programs. These studies, using second-generation sealants, have shown effectiveness results comparable to those of clinical trials, regardless of the physical delivery site or personnel used for sealant application. Complete retention after approximately 1 year varied from 83 to 94 percent (Calderone and Mueller 1983, Hardison 1983, Ismail et al. 1989, Sterritt and Frew 1988, Whyte et al. 1987).

A Consensus Development Conference sponsored by the National Institutes of Health concluded that "an extensive body of knowledge has firmly established the scientific basis for the use of sealants" (NIH 1984). The panel urged the development of educational materials to enhance public and professional acceptance as well as third-party reimbursement. Consensus on the value of sealants is reflected by the inclusion of sealant objectives in Healthy People 2000 and Healthy People 2010 (see Table 7.6). In addition, sealant placement is supported in federally funded programs for women and children, and sealants are covered services in all state Medicaid programs. A Workshop on Guidelines for Sealant Use has made recommendations for sealant use in both community and individual care programs (ASTDD 1995).

Community Dental Sealant Programs

Several community-based public health initiatives have arisen to promote sealant use among private practitioners and through community-based programs. These activities include reaching dentists through continuing education courses (Bader et al. 1987, Callanen et al. 1986, Siegal et al. 1996); directing large-scale promotional activities to consumers, community leaders, and third-party payers (Siegal et al. 1997a); and providing sealants directly to children in school programs.

Community programs that provide sealants directly to schoolchildren generally target vulnerable populations less likely to receive private dental care, such as children eligible for free or reduced-cost lunch programs. School-based programs are usually conducted entirely on site. School-linked programs conduct some portion of the program in schools, such as patient selection and parental permission, but generally provide the sealants at an off-site private practice or clinic. Nationally, 88 community-based sealant placement programs were in operation in the 1992-93 school year. These programs served children in 1,636 schools (Siegal et al. 1997b).

Combining Sealants with a Fluoride Program

Dramatic evidence of the impact of a combined fluoride and sealant program is provided by a program in Guam (Sterritt et al. 1990). For many years the children on this island had experienced dental caries rates more than double those of their U.S. mainland counterparts. In 1984 a school-linked pit-and-fissure sealant program was added to an existing school-based fluoride mouthrinse program. More than 15,000 children participated annually in the sealant program. After 8 years of fluoride mouthrinsing (from 1976 to 1984), mean decayed, missing, and filled surface (DMFS) scores declined by 1.79 surfaces per child. Only 7 percent of that decline was due to prevention of caries on surfaces that can benefit from sealants. With the addition of the sealant program to mouthrinsing, overall DMFS scores decreased an additional 2.34 surfaces per child in only 2 years. Most of this decline took place on pit-and-fissure surfaces. For the 10-year period a reduction of 4.13 DMFS per child was seen—a decline from 7.06 DMFS per child at baseline to 2.93 DMFS in 1986. At the end of the 10 years, participating children on Guam had caries rates close to those of mainland schoolchildren.

The National Preventive Dentistry Demonstration Program, a large project conducted in 10 U.S. cities between 1976 and 1981 to compare the costs and effectiveness of combinations of caries prevention procedures, found that the inclusion of sealants was critical to the cost-effectiveness of prevention strategies (Disney et al. 1989, Klein et al. 1985). In another combined program, Morgan et al. (1998) found that a 3-year sealant program and a fluoride mouthrinse program for secondary schoolchildren incurred a low cost for each tooth surface saved from caries. The incremental cost-effectiveness ratios comparing the intervention to the control group varied from a cost of $35.60 per tooth surface spared to a net savings of $7.00, depending on the assumptions used in the analysis.

Sealing Incipient Caries

Heller et al. (1995) evaluated the effect of sealants placed as part of a school-based program on permanent first molar teeth after 5 years. Sealants were applied to both sound teeth and those with incipient carious lesions (where the fissure is stained but not yet cavitated). For the initially incipient carious surfaces, the 5-year decay rate was 10.8 percent for sealed surfaces and 51.8 percent for unsealed surfaces. Initially sound surfaces had a decay rate of 8.1 percent for sealed surfaces and 12.5 percent for unsealed surfaces. Initially sound tooth surfaces were unlikely to become decayed in 5 years and did not benefit greatly from the application of sealants. The study showed potential efficiencies in targeting teeth with incipient caries for sealants.

Cost-effectiveness of Sealant Programs

Studies suggest that sealants are an efficient use of resources when used in populations with higher-than-average disease incidence rates and when selection methods limit sealants to teeth at highest risk of disease. Weintraub et al. (1993) demonstrated cost savings or improving cost-effectiveness with time in a sealant study at a children's dental clinic for low-income families. A strategy of identifying children with prior molar restorations (an indicator of high risk) and sealing the remaining molars showed cost savings within 4 to 6 years.

Summary: Dental Sealant Programs

Studies carried out during the last 20 years provide strong evidence to support the effectiveness of sealants in preventing the development of caries in tooth pits and fissures. Economic analyses suggest that community sealant programs are cost-effective and may even provide cost savings when used in high-risk populations. Experts recommend that programs should be limited to high-risk children and high-risk teeth.

TABLE 7.6
Baseline data for Healthy People 2010 objective 21-8a & b: increase the proportion of children who have received dental sealants on their molar teeth

	Percentage of Children Who Have Received Sealants[a]	
	Aged 8 Years	Aged 14 Years
2010 target	50	50
Total, 1988–94 baseline	23	15
Race and ethnicity		
American Indian or Alaska Native (1999)[b]	37	26
Asian or Pacific Islander	DSU	DSU
Asian	DNC	DNC
Native Hawaiian and other Pacific Islander	DNC	DNC
Black or African American	11	5
White	26	19
Hispanic or Latino	DSU	DSU
Mexican American	10	7
Not Hispanic or Latino	25	DNA
Black or African American	11	5
White	29	18
Gender		
Female	24	14
Male	22	16
Education level (head of household)		
Less than high school	17	4
High school graduate	12	6
At least some college	35	28
Disability status		
Persons with disabilities	DNC	DNC
Persons without disabilities	DNC	DNC
Selected populations		
Third-grade students	26	NA

[a] DNA = data have not been analyzed. DNC = data are not collected. DSU = data are statistically unreliable. NA = not applicable.

[b] Data are for IHS service areas.

Data sources: National Health and Nutrition Examination Survey (NHANES), NCHS, CDC; Oral Health Survey of Native Americans, 1999, IHS.

Source: USDHHS 2000.

PREVENTION AND CONTROL OF PERIODONTAL DISEASES

Periodontal diseases, caused by specific bacteria in dental plaque, affect most adults at some point in their lives. The mildest and most common form of periodontal disease is gingivitis. Over time, periodontitis, the more severe form of periodontal disease, can lead to the destruction of the soft tissue and bone that anchor the teeth into the jaw. Lacking support, teeth can loosen and be lost.

Periodontal diseases can be prevented and controlled through an array of mechanical and chemical means (Ismail and Lewis 1993, AAP 1996). Conscientious oral hygiene and professional oral cleanings to reduce plaque can reverse gingivitis (Löe et al. 1965).

Methods for personal oral hygiene include toothbrushing and flossing, which may be augmented by over-the-counter and prescription mouthrinses with antimicrobial action.

Community Programs to Prevent Gingivitis

With the confirmation of specific bacteria in dental plaque as the cause of gingivitis, public health officials began to seek ways to educate the public about plaque control in community settings, primarily in schools. These efforts have had equivocal results. Although knowledge and attitudes were enhanced in demonstration programs, improvements in plaque levels and gingivitis were short-lived in clinical trials (Horowitz et al. 1980).

Prevention of Periodontitis

Tobacco use is a major risk factor for the development and progression of periodontal diseases, and proven strategies aimed at reducing tobacco use should aid in the prevention of periodontitis. The following section on oral and pharyngeal cancers includes a discussion of such intervention strategies. Until recently, most interest in controlling tobacco use reflected concerns about oral cancers. As appreciation of the role of tobacco in the progression of periodontal diseases and tooth loss increases, attention to these oral health effects may increase attention to tobacco cessation in primary oral health care. Periodontitis can also be a complication of poorly controlled diabetes. (See Chapters 3 and 5 for a discussion of other periodontal risk factors; Chapter 5 discusses the connection between periodontal disease and diabetes.)

Some efforts have been directed at alerting dental practitioners to the need to educate patients about diseases affecting the periodontal tissues (Bader et al. 1990, Brown and Spencer 1989). These efforts have met with some success, but they tend to reach only those people who already use dental services. Currently, there are no broad community-based intervention programs that address periodontal diseases.

Summary

Gingivitis can be controlled with available methods, and its control is the principal way to prevent periodontitis. However, the currently available methods are individually or professionally based and require conscientious oral hygiene practices and regular dental visits. Although some schools instruct children in proper methods of oral hygiene, no community methods, other than programs designed to discourage tobacco use, are available for preventing gingivitis or periodontitis in the general population.

PREVENTION AND CONTROL OF ORAL AND PHARYNGEAL CANCERS

The term *oral and pharyngeal cancers* refers to a diverse group of tumors affecting the oral cavity and pharynx, the majority of which are squamous cell carcinomas. Usually included are cancers of the lips, tongue, pharynx, and oral cavity. These malignancies are among the most debilitating and disfiguring of all cancers. More than 30,000 new cases of oral and pharyngeal cancers are diagnosed each year, and more than 8,000 people die annually from these diseases. The overall 5-year survival rate (52 percent) has not changed in the past four decades (Murphy et al. 1995, Silverman 1998).

Primary risk factors for oral cancers in the United States are the use of tobacco and alcohol products and, for lip cancer, exposure to sun. Tobacco and alcohol independently increase the risk of oral and pharyngeal cancers and also act synergistically, so that persons who use both are at much higher risk than those who use only one. Other risk factors include insufficient fruits and vegetables in the diet, failure to use ultraviolet protection, and infection with certain viruses (Winn et al. 1998).

In 1996 CDC convened the National Oral Cancer Strategic Planning Conference to develop strategies for preventing and controlling oral and pharyngeal cancers in the United States. The conference, which was co-sponsored by the National Institute of Dental and Craniofacial Research and the ADA, included over 125 experts in oral and pharyngeal cancer prevention and control, treatment, and research (CDC 1998). These experts developed recommendations concerning public advocacy, collaboration, and coalition building; public education; professional education and practice; and data collection, evaluation, and research. An ongoing multidisciplinary subgroup from that conference, the Oral Cancer Working Group, met in 1997 and again in 1999 to share information on progress made and to discuss steps to implement a national plan. This group's work will augment existing interventions directed at the reduction of tobacco use, for which several community-based interventions have already been shown to be effective. The group is also developing several statewide models for the prevention and early detection of oral and pharyngeal cancers.

Many recommendations from the 1996 Strategic Planning Conference relate to the inclusion of primary prevention (i.e., reducing risk factors) and early detection. These include a recommendation that because people at high risk for oral cancers are more likely to visit a physician than a dentist, and because physicians may be less likely than dentists to perform an oral cancer examination on such patients, all primary care providers should assume more responsibility for counseling patients about behaviors that put them at risk for developing these cancers; should perform oral cancer examinations on all patients who are at high risk for developing the disease because of tobacco use or excessive alcohol consumption; and should refer patients to the appropriate specialist for management of suspicious oral lesions (CDC 1994c, Elwood and Gallagher 1985, Lynch and Prout 1986, Prout et al. 1990, Yellowitz and Goodman 1995). Further research is needed to better define screening parameters. Comprehensive education of medical and dental practitioners in diagnosing and promptly managing early lesions was recommended to facilitate the multidisciplinary collaboration needed to detect oral cancers in their earliest stages. Furthermore, because of the public's lack of knowledge about the risk factors for oral cancers and because these diseases can often be detected in the early stages, it is also recommended that programs to raise the public's awareness of oral cancers (including their risk factors, signs, and symptoms) be increased.

Community-based Interventions

Community-based interventions for oral and pharyngeal cancer prevention have depended on tobacco control programs.

School-based Prevention Programs

On average, more than 3,000 children and teenagers become regular smokers each day (USDHHS 1994). Prevention efforts aimed at young people are extremely important because nearly all initiation of tobacco use in the United States occurs by age 18. Moreover, the finding that the earlier that smoking begins the more likely it is to lead to heavy use in adulthood makes preventing tobacco use among school-age youth all the more critical (CDC 1994a).

Programs identifying the social influences that foster tobacco use in schoolchildren and teaching skills to resist such influences have yielded consistent and significant results. Reductions or delays in adolescent smoking have been documented, ranging from 25 to 60 percent and persisting from 1 to 4 years (CDC 1994b). The interventions were based on a CDC review of published research, including the conclusions of the National Cancer Institute's (NCI) Expert Advisory Panel on School-based Smoking Prevention Programs and findings from the 1994 Surgeon General's report, *Preventing Tobacco Use Among Young People* (CDC 1994b). The *Guidelines for School Health Programs to Prevent Tobacco Use and Addiction* cites seven recommendations (CDC 1994a,b):

1. Develop and enforce a school policy on tobacco use.
2. Provide instruction about the short- and long-term negative physiologic and social consequences of tobacco use, social influences on tobacco use, peer norms regarding tobacco use, and refusal skills.
3. Provide tobacco-use-prevention education in kindergarten through 12th grade; this instruction should be especially intensive in junior high or middle school and reinforced in high school.
4. Provide program-specific training for teachers.
5. Involve parents or families in support of school-based programs to prevent tobacco use.
6. Support cessation efforts among students and all school staff who use tobacco.
7. Assess the tobacco-use-prevention program at regular intervals.

A major part of most successful interventions has been the decrease of illegal sales to minors. This strategy has been accomplished by increasing merchant education and enforcement of laws prohibiting tobacco sales to minors under 18 and increasing the cost of cigarettes (CDC 1994a,b, Lewit et al. 1997, Lynch and Bonnie 1994). All 50 states and the District of Columbia have laws prohibiting the sale of tobacco, including smokeless (spit) tobacco, to minors.

In recent years, attempts to prevent and reduce the use of spit tobacco have increased. These informational and educational efforts have largely targeted baseball clubs, Little League baseball teams, and 4-H Club members. A major new initiative, the National Spit Tobacco Education Program, has been launched by Oral Health America, with support from NIH and CDC and funding largely from the Robert Wood Johnson Foundation in collaboration with the Major League Baseball Players Association, to help break the link between spit tobacco and Major League Baseball.

Other Program Models

The majority of community programs designed to prevent or reduce the use of tobacco products have focused on cigarette smoking. Initially, NCI funded randomized trials of interventions to prevent smoking in adolescents and promote cessation in adults. The value of multiple interventions delivered through multiple channels was confirmed in NCI's Community Intervention Trial for Smoking Cessation (COMMIT 1995a,b).

Findings from more than 100 intervention trials continue to provide important information about how to reach smokers and potential smokers. A major conclusion from these studies is that large-scale reductions in smoking prevalence are unlikely when interventions focus on the individual, but that interventions can be effective when community-based. Further, researchers found a statistically significant difference in the proportion of light-to-moderate (but not heavy) smokers who quit in the intervention communities compared with control communities (COMMIT 1995a,b, Klausner 1997, NCI 1995).

Findings from COMMIT and other studies in the United States and abroad led to planning for ASSIST (American Stop Smoking Intervention Study for Cancer Prevention). In 1990, California adopted the ASSIST model, and early success in the California Statewide Tobacco Control Program clearly showed an impact on per capita cigarette consumption in that state compared with consumption in the United States as a whole (Manley et al. 1997a,b, Shopland 1993). The ASSIST model uses surveillance systems that allow for time-series analysis designs comparing intervention and control communities. Media-led tobacco control campaigns, as well as efforts to increase state excise taxes on cigarettes and thereby discourage teenagers from smoking, are included in the model.

There are now dedicated tobacco-control coalitions in all 50 states, and the Agency for Healthcare Research and Quality (formerly Agency for Healthcare Policy and Research) has developed clinical practice guidelines on smoking cessation to aid health professionals in interventions with patients (Fiore 1997).

Although the major focus in reducing the risk for oral and pharyngeal cancers has been on tobacco cessation programs, reduction in alcohol use is clearly indicated. Currently, alcoholic beverages carry the Surgeon General's warning label stating that pregnant women should not drink because of the risk of birth defects and admonishing that alcohol impairs the ability to drive and operate machinery and may cause other health problems. Many communities have programs that stress responsible drinking by adults related to the use of motor vehicles and completely discourage drinking among young drivers. Community approaches have also been developed to discourage drinking among young people. Targets are youth and adults who are at risk for alcohol-related problems, such as college students who may need to develop skills to avoid binge drinking, or women attending women's clinics who might not know the risk of fetal alcohol syndrome. Because alcohol use, like tobacco use, usually begins in adolescence, development and testing of community- and school-based programs that provide youth with the skills to avoid alcohol use are warranted.

Early Diagnosis of Oral and Pharyngeal Cancers

Primary care providers can counsel patients about lifestyle behaviors that increase the risk for oral cancers. Dental as well as medical personnel have provided successful tobacco control programs in their offices (see Chapter 8). Generally, Americans are ill-informed about the risk factors as well as the signs and symptoms of oral cancers (Horowitz and Nourjah 1996, Horowitz et al. 1995). The mass media have paid little attention to the topic, and health education textbooks are nearly devoid of discussion (Canto et al. 1998b, Chung et al. 2000, Gold and Horowitz 1993, Horowitz et al. 1998). The scant attention that has been paid to oral cancers has focused on the role of spit tobacco.

At present, the principal test for oral and pharyngeal cancers is a comprehensive clinical examination that includes a visual/tactile examination of the mouth, full protrusion of the tongue with the aid of a gauze wipe, and palpation of the tongue, floor of the mouth, and lymph nodes in the neck. The U.S. Preventive Services Task Force concluded that there was insufficient evidence to recommend for or against routine screening for oral cancers, but noted that clinicians should remain vigilant for signs and symptoms of oral cancers and premalignancy in people who use tobacco or regularly use alcohol (USPSTF 1996). The Canadian Task Force on Periodic Health Examination (1997) states that although there is insufficient evidence to include or exclude screening for oral cancers from the periodic health examination for the general public, those at high risk (smokers and heavy drinkers) over 60 warrant an annual oral cancer exam by a physician or dentist (Lewis and

Ismail 1995). The American Cancer Society recommends annual examinations for individuals 40 and older and for individuals who are exposed to known risks. Nevertheless, a 1992 national survey showed that only 15 percent of U.S. adults reported ever having had an oral cancer examination (Horowitz and Nourjah 1996).

There are large gaps in knowledge of the efficacy of oral cancer examinations and the effectiveness and cost-effectiveness of community approaches to early detection of oral cancers. Methodologies and settings differ across studies. Moreover, these studies do not provide definitive evidence supporting the oral cancer exam, and there have been no controlled clinical trials for defining the effectiveness of screening programs. Further research is thus needed.

Summary

Although no school- or community-based interventions specifically designed for the prevention or early detection of oral and pharyngeal cancers are now in place, scientists representing the agencies in the newly formed oral cancer consortium have begun to develop statewide model protocols, beginning with the state of Maryland. In the meantime, any program that aims at eliminating tobacco use will reduce the primary risk factor for oral and pharyngeal cancers, along with other tobacco-related diseases. The evidence on the effectiveness of school-based programs to prevent tobacco use and addiction among children and adolescents provides strong support for their use as part of the school health education curriculum. Further, other community-based interventions such as COMMIT and ASSIST are recommended because they have demonstrated effectiveness in getting light-to-moderate smokers to quit. After reviewing the evidence, an expert panel convened by AHCPR (now the Agency for Healthcare Research and Quality) recommended that all primary care clinicians be trained to provide smoking cessation activities (see Chapter 8). In addition, providers should perform oral cancer examinations on high-risk persons regularly. The recommendation to use all of these interventions to prevent or cease tobacco use in communities is based on expert opinion.

Oral cancers occur in sites that lend themselves to early detection by most primary health care providers and, to a lesser extent, by self-examination. Heightened awareness in the general population could help with early detection and could stimulate dialogue between patients and their primary health care providers about behaviors that may increase their risk. Recent advances in understanding the molecular events involved in developing cancer might provide the tools needed to design novel preventive, diagnostic, prognostic, and therapeutic regimens to combat oral cancers. Acquiring greater knowledge of the biology, immunology, and pathology of the oral mucosa may also help reduce the morbidity and mortality from these cancers.

PREVENTION AND CONTROL OF CRANIOFACIAL BIRTH DEFECTS

The causes of craniofacial birth defects are often complex and multifactorial—the result of gene-environment interactions occurring from the time of conception to birth. Even when a mutation in a single gene has been discovered as the cause of a particular syndrome, there can be considerable variation in susceptibility, with some infants showing little or no sign of a problem and others experiencing multiple organ defects.

The work to complete the mapping and sequencing of the human genome will undoubtedly shed light on the hundreds of genes involved in craniofacial development and provide details on when and how they function in development. This knowledge may in turn lead to gene therapies that restore or "rescue" the function of a defective gene and thus prevent the anomaly.

Craniofacial defects also may occur because the susceptible embryo or fetus was exposed to an environmental teratogen, a diminished oxygen supply, or a deficit in an essential nutrient. Chapter 5 reports an association between low-birth-weight, premature babies who may show other subtle craniofacial anomalies and mothers with chronic oral infectious disease. In addition, diets poor in folic acid increase the risk of spina bifida and possibly clefting syndromes. Clinical trials using vitamin supplementation with varying levels of folic acid are under development to determine if they can lower the risk of clefts in high-risk pregnancies. Outcomes of clinical trials of nutrient supplementation in pregnancy may lead to new nutritional guidelines and the development of enriched food products, which can form the basis for community-wide health promotion and disease prevention programs.

Given the array of variables affecting prenatal growth and development, the key to public health programs aimed at preventing birth defects lies primarily in health promotion and education campaigns. Individuals need to be made aware of known risk and protective factors in pregnancy. Such programs should emphasize the importance of good nutrition, avoidance of tobacco and alcohol use, and

prenatal care. Education includes knowledge about the teratogenic effects of prescription drugs, such as the antiepileptic drug phenytoin and the retinoic acid drugs used to treat cystic acne.

Summary

As information from developmental biology, genetics, and epidemiologic and clinical studies accrues, dental care providers are better positioned to provide counseling. The public is best served by health promotion and disease prevention campaigns that communicate findings about risk and protective factors in pregnancy.

PREVENTION AND CONTROL OF INTENTIONAL AND UNINTENTIONAL INJURY

Intentional and unintentional injuries are related to behaviors and are thus amenable to prevention. As studies of motor vehicle and sports injuries have demonstrated, injuries are frequently due to a sequence of predictable events, and a public health approach can be successful in injury prevention and control.

The interventions that have proved to be most effective in controlling injuries have been passive; that is, they do not require the individual to participate. Examples include the use of environmental controls such as vehicle and roadway design, speed limits, passenger restraints, and airbags to prevent injuries from motor vehicle collisions (Karlson 1992, Smith and Falk 1987). Passive measures such as these are more easily implemented at the state or federal level. However, many preventive measures for oral-facial injuries have been directed at the individual and professional health service levels, rather than at the population at large (see Table 7.7).

Craniofacial Injuries

The principal causes of craniofacial injuries are motor vehicle collisions, falls, assaults, and sporting activities. Except in relation to sports, injuries to the craniofacial region have received little attention. These injuries are hardly insignificant, however, and efforts to prevent them are gaining acceptance. For example, to increase public awareness of the importance of facial protection, the inaugural National Facial Protection Month was celebrated in April 2000. This national campaign, providing information to the media and the public, was sponsored by the American Association of Oral and Maxillofacial Surgeons (AAOMS 2000).

Motor vehicle collisions are the leading cause of death during the first three decades of life in the United States and the leading cause of death from injury over most of the life span (Baker et al. 1992). Data from multiple sources indicate that craniofacial injuries account for a substantial subset of these injuries annually (USDOT 1998). Even though it is likely that passive measures enacted to reduce fatalities have reduced nonfatal craniofacial injuries, no supporting data exist.

Various sources report the number of motorcycle- and pedal-cycle-related craniofacial injuries. Data from the National Electronic Injury Surveillance System indicate that head injuries account for 50 percent of all pedal-cycle-related injuries; of those, bicycle-related events accounted for 19 percent of all facial injuries within the study period (McDonald 1994). In similar studies, tricycle-related incidents were found to be responsible for up to 61 percent of injuries to the head, face, or mouth (CDC 1987, USCPSC 1986). Motorcycle injuries are a major source of fatal and nonfatal head trauma in the United States (Rivara et al. 1988).

Helmet use reduces head and facial injuries among bicyclists (Acton et al. 1995, Grimard et al. 1995, Rivara et al. 1997) and motorcyclists (Bachulis et al. 1988, Johnson et al. 1995, Lee et al. 1995) by up to 50 percent. Health promotion efforts have increased acceptance at the community level for helmet use by bicyclists; however, helmet use regulations vary by state (Sacks et al. 1996) and with the public whim (Sosin et al. 1990). Over a dozen states currently have bicycle helmet laws, and half of the states have motorcycle helmet laws (NCHS 1992).

Many authors have described craniofacial injuries related to sports. Information is usually obtained from community or regional surveys of injuries or mouthguard use and effectiveness. Craniofacial injuries sustained during sporting activities are a major source of nonfatal injury and disability (Baker et al. 1992), possibly accounting for up to one third of all sports injuries (Cathcart 1982, Meadow et al. 1984). The increasing participation of women in competitive sports means that young women should be alerted to the risks and advised of the need for additional protective gear as appropriate. The most comprehensive data on the effectiveness of protective equipment have been collected by agencies such as the National Alliance of Football Rules Committee, the National Collegiate Athletic Association, and the U.S. Consumer Product Safety Commission. Data on craniofacial injuries from participation in football before and after the enactment of mandatory mouthguard regulations indicate a

TABLE 7.7
Community-based interventions for the prevention and control of craniofacial injuries

	Restraints and Airbags	Helmets	Mouthguards
Guidelines for use	Combination of manual lap and automatic shoulder restraints plus airbag; emphasis on passive systems to overcome noncompliance	Cyclists, both motorized and nonmotorized, wear approved protective helmets, preferably with a full face mask for motorcyclists	**Football:** Wear helmet with face mask and use mouthguard **Hockey:** Wear helmet with face mask and use mouthguard because face shields do not prevent injury to lower face
Public policies	**Restraints:** Mandatory use required by law in 48 states **Airbags:** All late model vehicles required to have driver-side airbags, and future models to add passenger-side airbags; National Traffic and Motor Vehicle Safety Act legislates policies	• 13 states have bicycle helmet laws; 25 have motorcycle helmet laws • Post-law bicycle helmet use rates increase by up to 50 percent among children (National Center for Injury Prevention and Control 1995) • States with helmet use laws have higher rates of helmet use	**Football:** Requirement since 1962 for mandatory mouthguard use in football accompanied by significant decline in incidence of oral-facial injuries **Hockey:** Mandatory requirement for full facial protection in Canada has reduced facial injuries among youth (Rampton et al. 1997)
Utilization rates	**Restraints:** Compliance with seatbelt laws ranges from 29 to 74 percent (Reinfurt et al. 1991); current use may be as high as 67 percent (NCHS 1992) **Airbags:** Utilization may become an issue if on-off switch is implemented	**Bicycle:** Approximately half of bicyclists own a helmet, and half of those consistently wear it (Sacks et al. 1996); 62 percent of motorcyclists and 17.6 percent of bicyclists wear helmets (NCHS 1992)	**Football:** 72 percent of children wear headgear and mouthguards **Baseball/softball:** 35 percent of children wear headgear; 7 percent consistently wear mouthguards **Soccer:** 4 percent of children wear headgear; 7 percent of children wear mouthguards (Nowjack-Raymer and Gift 1996) **Basketball:** 4 percent of respondents reported wearing mouthguards (Maestrello-deMoya and Primosch 1989)
Type of evidence for effectiveness and PHS ratings	• **Hospital and trauma registry studies** (Sutyak et al. 1997, Orsay et al. 1990) • **Modeling** from insurance studies (Sorenson 1993) • **Case-control study** (Marine et al. 1994)	• **Hospital and trauma registry studies** (Bachulis et al. 1988, Johnson et al. 1995) • **National survey** (Sacks et al. 1996) • **Case-control study** (Thompson et al. 1996)	• **Hospital and trauma registry studies** • **Questionnaire (baseball and basketball)** • **Before and after** NFA rule in 1962 • **Descriptive survey** (Maestrello-deMoya and Primosch 1989)
Evidence for effectiveness	**Restraints:** Use reduces facial injuries by 30 percent (Orsay et al. 1990) **Airbags:** Projected facial injury harm reduction of up to 90 percent for airbag added to restraint (Sorenson 1993); report of facial injuries may increase with airbags due to a decrease in fatalities and more severe injuries (Blacksin 1993)	**Motorcycle:** A twofold decrease in incidence of maxillofacial trauma in helmeted versus nonhelmeted motorcyclists (Bachulis et al. 1988); nonhelmeted 3 times more likely to have facial fractures than those with helmets (Johnson et al. 1995) **Bicycle:** Helmet wearers have a 65 percent reduction in upper- and mid-face injuries (Thompson et al. 1996); head injuries decreased 67 percent in children concomitant with rate of helmet use increase of 35 percent following educational campaign (Rivara et al. 1994); helmets with face protection decrease facial injuries by a factor of 3 (Vaughan 1977); helmet wearing alone is not sufficient to prevent serious injury and fatality (Rivara et al. 1997)	**Football:** Face mask reduces oral-facial injury by 50 percent; addition of a mouthguard reduces risk to less than 1 percent (AAHPER 1960) **Hockey:** Full-face protection reduced chance of upper facial injury; half visor same as no face protection (Rampton et al. 1997) **Baseball and basketball:** 60 times more likely to sustain oral injury without mouthguard (McNutt et al. 1989); 30 percent reduced risk of oral-facial injury for those wearing mouthguards (Powers et al. 1984)

	Restraints and Airbags	Helmets	Mouthguards
Risks	**Restraints:** • Improper car seat design and use for infants **Airbags:** • Concern regarding higher risk for death in children and small women • Case report of facial desquamation from ruptured airbag	• No injuries have been documented secondary to the helmet itself; helmets do not decrease risk of injury to lower face, mandible, and mouth	Costs are high because mouthguards should be fabricated for each individual by a health professional
Costs and effectiveness	**Airbags and restraints:** U.S. costs are calculated for all injuries or fatalities, not craniofacial injuries; Australian report estimated savings of 108 million (Australian) dollars per year due to facial injury reduction (Sorenson 1993)	**Bicycle:** Hospital treatment costs for bicyclists estimated at $1 billion annually—includes mortality and morbidity (Sacks et al. 1996)	**Hockey:** Direct costs: 3 million (Canadian) dollars annually (Rampton et al. 1997)
Recommendations (abstracted from CDC 1987, USDHHS 2000)	• Extend safety belt laws to all 50 states • Increase airbag efficacy and safety research for craniofacial injuries	• Helmets should meet recommended industry manufacturing standards • Implement national mandatory helmet requirement law for motorcyclists in all states • Implement national mandatory helmet requirement law for child bicyclists in all states—strongly recommend helmet use for adult bicyclists • Combine helmet use with education and health promotion and environmental controls (e.g., separation of cyclists and motor vehicles, features to make cyclist more visible) • State and local health departments should engage in health promotion for helmet use, develop and work for legislation for mandatory helmet use, and evaluate programs	• Extend mandatory mouthguard use for all team sports sponsored by organizations, agencies, and institutions • Utilize health promotion and education of trainers, athletes, and parents to increase use of protective sporting equipment

significant decline in craniofacial injuries (Sane 1988). Further, the U.S. Consumer Product Safety Commission's review of National Electronic Injury Surveillance System data showed that mouth injuries were more frequent in baseball than in any other sport monitored (USCPSC 1981). These combined reports were instrumental in implementing policies for protective equipment use in these two sports. (See Box 7.2, Sports Injuries and Oral-Facial Trauma.)

Research on elderly and disabled individuals has led to the development of safety measures to prevent unintentional injuries from falls in the home. These include installing adequate lighting and handrails, using nonskid materials on floors and in bathrooms, and positioning furniture to reduce the risk of tripping. Wider distribution and adoption of such safety measures should lower the risk of oral and craniofacial injuries due to falls for the general population as well, not only in the home but also in the workplace and other settings.