

Chapter 2

The Oral Disease Burden Faced by Older Adults

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Introduction

By the year 2030, one in five Americans will be 65 or older, and this age group will require a proportionally larger share of the national health care expenditure than at present. When referring specifically to oral health care services, addressing this challenge begins with an understanding of the patterns of oral disease faced by older adults.

This discussion is important for a number of reasons. First, these developments alert the dental profession to both current levels of disease and anticipated shifts in the future as the population ages. This knowledge will suggest preventive approaches and allow the educational system (dental schools and continuing education programs for dental professionals) to offer appropriate and timely information. Second, increased awareness will prepare the dental profession to address these problems and thereby have a positive impact on the health and well-being of patients. Loss of teeth, oral cancer and reduced masticatory function are just some consequences of oral disease that will affect morbidity, mortality and quality of life. Third, recent interest in the relationship between oral infection/periodontal disease and systemic diseases (cardiovascular/cerebrovascular disease, diabetes mellitus, respiratory diseases) has particular relevance for older individuals since many of these relationships disproportionately affect the elderly. Meurman and Hamalainen (2005) observed that oral infections have a more profound effect upon the elderly compared to other segments of the population. Further, older individuals (at least 85 years of age) needing immediate dental treatment were at nearly four times the risk of death when followed for a 5-year period (Hamalainen et al. 2005). However, few clinical studies examining the relationship of oral infection and systemic diseases have focused solely on older adults. Fourth, this information will provide background for discussion of public and private approaches to address the need for oral health care services in an aging population. Any attempts

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to define national, state or local oral health care policy with a focus on older adults will require information about the disease burden. This is a critical matter since Medicare, which was developed to address the medical care needs of seniors, does not provide dental benefits. Consequently, a significant portion of the population of older adults will not be able to afford appropriate dental services.

A review of the prevalence of oral diseases affecting older adults will provide some insight into the future needs of the population. This concept is relevant here since one of the sentinel measures of oral health status – the number of remaining teeth or the percent of the population who are edentulous – is changing in the United States and other developed countries. Tooth retention is increasing as the population ages. This trend will obviously have an important impact on both the oral disease burden (since there will be a larger number of teeth that are susceptible to dental disease) and the anticipated need for dental services in the future.

This chapter will examine the oral disease burden faced by older adults by focusing on three major oral diseases: dental caries (with discussion of tooth loss and edentulism), periodontal diseases and oral cancer. A more limited discussion of mucosal disorders and candidiasis and myofacial pain/disorders of the temporomandibular joint is also included.

Dental Caries and Tooth Loss

Overview

Dental caries is an infectious disease that requires the presence of bacteria (*Streptococcus mutans*, *Lactobacillus* species), a substrate (fermentable carbohydrate) and a susceptible host. The byproducts of bacterial metabolism of carbohydrate include lactic acid and uric acid, which can lead to demineralization of the enamel and dentin. When the tooth root is exposed, the cementum covering the root surface is also affected. Dental caries can occur as coronal caries, root caries (Fig. 2.1) and recurrent caries (caries associated with existing dental restorations). When the caries process extends into the root canal system, the result can be necrosis of the pulp tissue. This last phase is frequently accompanied by acute infection and clinical findings of pain and swelling.

The prevalence and extent of dental caries is dependant upon the number of teeth present in the mouth. As the number of teeth increases, the number of susceptible tooth surfaces increases. Further, tooth loss can be a result of caries, periodontal disease, trauma and elective extraction for prosthetic or orthodontic reasons, among other causes.

Prevalence and Incidence

The literature suggests that in many countries with a relatively high standard of living, the percent of the older population that is edentulous is in decline (Surgeon

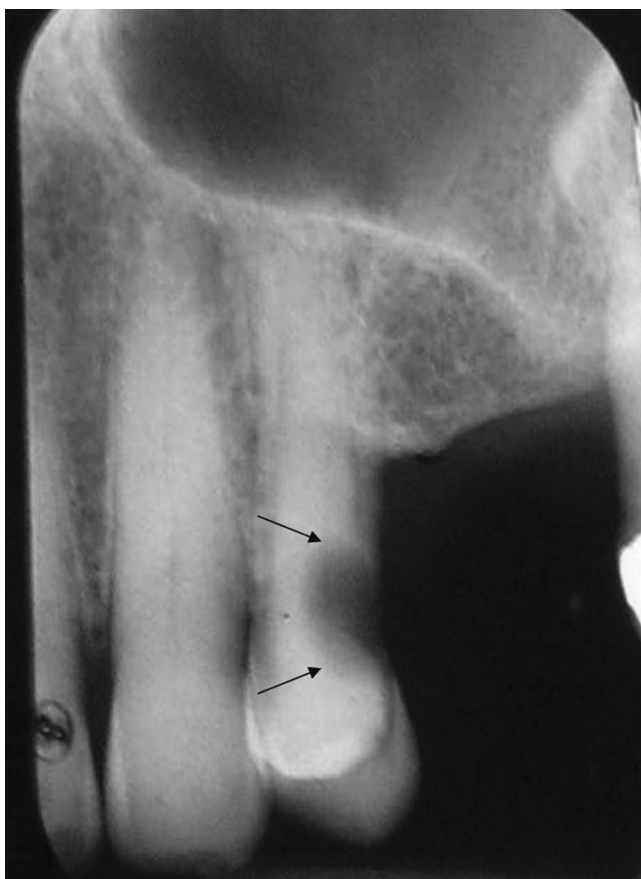


Fig. 2.1 Radiograph illustrating a large carious lesion on the distal root surface of a maxillary first bicuspid tooth (arrows)

General's Report 2000a, Petersen et al. 2004). As a result, a larger percentage of older patients will be susceptible to tooth-related oral diseases. Nevertheless, edentulism is common throughout the world and is generally linked to lower socioeconomic status (Petersen and Yamamoto 2005).

A study from Sweden indicated that between 1971 and 2001, the percentage of 70-year-old individuals who were edentulous decreased from 51% to 7%. Further, the mean number of teeth increased from 14 to 21 (Österberg et al. 2006). Similar but less substantial declines have been reported from the United States, based on a comparison of the First and Third National Health and Nutrition Examination Surveys (NHANES). Between 1971–1974 and 1988–1994, the percent of individuals between 65 and 74 who were edentulous declined from 45.6% to 28.6% (Surgeon General's Report 2000). However, there are distinct geographic differences in edentulism in the United States. Based on data from the Behavioral Risk

Factor Surveillance System survey, the percent of individuals at least 65 years of age who have lost all of their teeth varied from a high of 42.3% in Kentucky to a low of 13.1% in Hawaii (Gooch et al. 2003, see Table 2.1).

Dental diseases (caries, periodontal disease) can be considered cumulative, and a study of the oral health status in China is revealing in regards to the effect of aging on the status of the dentition. The study is noteworthy in that more than 140,000 individuals were examined. The average number of teeth that were present in 12 year olds, 15 year olds, 18 year olds, adults 35–44 years of age and older adults 65–74 years of age were 25.8, 27.9, 27.9, 27.1 and 18.4, respectively. In addition, the caries exposure was much higher for older adults. The Decayed, Missing and Filled Teeth (DMFT) scores were 1.0, 1.4, 1.6, 2.1 and 12.4, respectively, for subjects in each group. Lastly, it was interesting to note that the percent of edentulous individuals in the 65 to 74-year-old group was only 10.5% (Wang et al. 2002). This is a relatively low percentage of edentulism in comparison to other countries, which may be related in part to a lack of dental services to accomplish removal of teeth that should be extracted.

Studies examining tooth loss have reported both the cause of tooth loss and risk factors associated with tooth loss. Fure (2003) reported on tooth loss in an elderly Swedish population. A 10-year follow-up of 55, 65 and 75-year-old individuals demonstrated that an increase in the number of teeth retained occurred with an increase in dental care services received by study participants. Nearly half of the participants had not lost any teeth after 10 years of follow up, and only 13% of participants had lost three or more teeth. Fure also found that while root caries increased with age, coronal caries decreased with age. Further, the main reason for tooth loss was caries.

The available data suggest that when assessed over time, older adults are at high risk for dental caries. At the 10-year follow-up examination, Fure (2004) observed that carious lesions occurred in 95% of the patients and the caries experience increased with age. As an example, for 85-year-old individuals, 25% of root surfaces demonstrated caries, versus 9% for individuals who were 65 years old. Recurrent or secondary caries (associated with existing restorations) were more common than primary lesions.

Table 2.1 Percent of individuals of age 65 and older who reported loss of all teeth (by state). The five highest and lowest states are provided

Highest	Lowest
Kentucky 42.3% (± 3.3)*	Hawaii 13.1% (± 2.9)
West Virginia 41.9% (± 3.7)	California 13.3% (± 2.7)
Tennessee 36.0% (± 4.1)	Utah 14.7% (± 3.3)
Mississippi 35.1% (± 3.7)	Minnesota 14.8% (± 2.5)
Louisiana 33.8% (± 3.5)	Connecticut 16.0% (± 2.5)

*95% confidence interval

Data are from the Behavioral Risk Factor Surveillance System, 2002; From Gooch et al. 2003

Warren and colleagues (2000) reported that among rural Iowans aged 79 years or older, 96% had coronal caries experience and 23% had untreated coronal caries. A history of root caries was found in 64% of individuals and 23% had untreated root caries. This group was unusual in that dental utilization was high. Over 70% reported a dental visit in the last year and most patients paid for their dental services.

A study from Japan confirmed that non-institutionalized elderly populations (70 years of age) are at high risk for caries. Over a 2-year period, almost 36% of adults 70 years and older developed one or more root caries lesions (Takano et al. 2003). Similarly, the oral health component of the Study of Health in Pomerania, Germany (Mack et al. 2004), revealed that in a representative sample of adults 60 years and older, root caries was an important problem. For individuals 60–79 years of age, coronal caries were observed on 2% of all teeth, while restorations on root surfaces were seen in 6% of teeth and root caries lesions were seen on 2% of teeth. For the entire population, 11% had one or more untreated coronal lesions and 27% had one or more untreated root lesions. Imazato and colleagues (2006) examined root caries prevalence among community-dwelling Japanese elderly (mean age was 65.8 years). Nearly 40% had one or more untreated root lesions, and more than 50% had one or more restored or untreated lesions.

While caries appears to be the primary reason for tooth loss experience by older adults living in developed countries, another study indicated that severe attachment loss (a surrogate for periodontitis) was a risk factor for tooth loss ($OR = 2.4$, $p = 0.006$). Of interest in this study, the number of remaining teeth had a significant positive effect on the patient's ability to masticate as well as their interest in smiling (Warren et al. 2002).

Evidence suggests that older adults who reside in long-term care facilities are at even greater risk for caries than non-institutionalized individuals of comparable age. Chalmers and colleagues (2005) examined the oral health status of residents of seven nursing homes in Adelaide, Australia. Residents were examined at baseline and 1 year later. All residents demonstrated major medical, mental and/or behavioral impairments. At baseline, the mean age of those examined was 82.3 years, two-thirds of the 224 patients were edentulous, 64% of the residents displayed coronal caries and 49% displayed root caries. In the 1-year interval between examinations, 72% of the residents demonstrated new carious lesions. The investigators noted that compared to community-dwelling older adults in Adelaide, nursing home residents displayed much higher prevalence and incidence of dental caries.

Similar findings have been reported in other studies. Data from a single nursing home in Zagreb, Croatia, revealed that of the 139 residents who were examined, 45% were edentulous. Thirty-one percent of the residents demonstrated untreated caries and an average of nine teeth per resident required treatment (Simonkovic et al. 2005). A study from Finland (Peltola et al. 2004) evaluated the oral health conditions and treatment needs of a group of 260 individuals, 60 years and older, who lived in a long-term care facility. Mean age was 83.3 years, and the average time of residence was 2.2 years. Forty-two percent were edentulous, and denture hygiene was considered 'good' in less than 20% of subjects. Among those with teeth, the

mean number was 12.4. In general, oral hygiene was poor, and 37% of individuals required restorations and 42% required tooth extraction. The authors concluded that for individuals unable to care for themselves, there is a significant need to provide assistance with oral hygiene and basic oral health care services.

Determinants and Etiology

Overall, these studies indicate a relationship between tooth loss and caries, and in particular root caries in older individuals. Identification of risk factors for caries in older adults helps to define preventive and treatment strategies for these individuals.

Curzon and Preston (2004) contrasted dental caries affecting the elderly to nursing bottle caries affecting young children. Nursing bottle caries was identified many centuries ago, while dental caries affecting the elderly is a relatively recent problem that relates to increased longevity and retention of teeth for a lifetime. They listed the most important risk factors for recurrent coronal caries and root caries affecting the elderly as increased intake of fermentable carbohydrates, increased plaque accumulation due to the presence of dental restorations and prostheses, reduced dexterity, incapacitation, limited access to professional dental services and reduced salivary flow that is a side effect of a number of medications. Studies have supported the multifunctional nature of caries, and root caries in particular, affecting the elderly. A study of clinical and behavioral risk factors for the development of root caries examined 462 dentate older adults (≥ 65 years of age) who were part of the National Diet and Nutrition Study from Great Britain (Steele et al. 2001). The subject sample was representative of the British population and included 405 individuals who were community dwelling and 57 who were in residential homes and long-term care facilities. The significant risk factors for root caries included the consumption of nine or more intakes of sugar per day (OR = 2.4), the presence of a partial denture which was associated with heavy plaque deposits (OR = 1.6) and less than one daily oral cleaning (OR = 4.7). The authors concluded that these are modifiable risk factors that can be used to develop a preventive strategy for improved oral health of older adults.

In a study of 549 community-dwelling older adults in Thailand (mean age of 66.7 years), root caries lesions were seen in 18.2% of individuals (Nicolau et al. 2000). After adjusting for the effects of other determinants in a multivariate logistic regression model, important risk factors for root caries were more years of education (OR = 2.39, $p = 0.002$), higher income (OR = 1.85, $p = 0.029$), being male (OR = 1.76, $p = 0.031$) and having at least 25 teeth (OR = 1.14, $p < 0.001$). The association of more years of education and higher income with greater prevalence of root caries may appear counterintuitive. The authors note that the literature is unclear regarding these associations. A number of explanations can be proposed. For example, this finding may be related to increased frequency of tooth brushing and resultant exposure of root surfaces seen in individuals with more years of education and higher income. Imazato et al. (2006) evaluated 287 community-dwelling older adults and identified a high prevalence of root caries.

For those individuals who had at least 20 teeth, there was a strong tendency for root caries to be associated with the report of having a dry mouth ($p = 0.052$) and actual reduced salivary flow ($p = 0.059$). Fewer root caries lesions tended to be associated with increased frequency of brushing ($p = 0.058$).

Periodontitis is associated with loss of periodontal ligament and attachment of the bone to the tooth, which often results in exposure of the vulnerable root surface to plaque accumulation. A study by Saotome et al. (2006) made an important contribution to our understanding of root caries affecting older adults. Studying a large group of 75-year-old individuals, they demonstrated that the presence of periodontitis, as measured by increased clinical attachment loss, was associated with increased levels of lactobacilli, microorganisms that have been associated with the development of root caries lesions. In turn, these individuals were at increased risk for root caries.

Xerostomia is a well-recognized risk factor for dental caries (See Chapters 9 and 15). Saliva has an important protective role, likely related to its buffering capacity. Thomson et al. (2002) followed a group of 528 older adults 60 years of age or older for 5 years. In addition to clinical examinations, the use of medications was recorded at baseline and then at the follow-up examination. Over the course of the trial, the incidence of coronal caries was 67% and root caries was 59%. Data for a total of 20 medication categories were recorded. For coronal caries, use of a β -blocker or antiasthma medication was associated with increased caries risk. For root caries, none of the drug categories were associated with an increased caries risk. The antiasthma drugs were also associated with the sensation of dry mouth. They noted that it is possible that patients using multiple medications will present to the dentist complaining of a dry mouth, unaware of the development of new carious lesions. Therefore, considering the many influential variables, there is a need for more research on the association of polypharmacy and the risk for dental caries in the elderly.

Lastly, much of what has been learned about risk factors for dental caries has been translated into a risk assessment tool that can be used in the clinical management of patients, including elderly patients. A computer-based assessment tool known as the Cariogram has been developed for dental caries (Bratthall 1996; Bratthall and Petersson 2005). The components of the model include: caries experience, related diseases, diet content, frequency of food intake, plaque, infection with *Streptococcus mutans*, fluoride use, rate of saliva secretion, buffering capacity of saliva and clinical judgment. A recent report demonstrated application of this tool for older adults (Alian et al. 2006).

Periodontal Diseases

Overview

The periodontal diseases are a group of inflammatory disorders that affect the supporting non-mineralized and mineralized tissues of the teeth. These disorders begin with bacterial infection and plaque accumulation at the margin of the gingival tissue,

which is followed by infection of the gingival crevice, the cuff formed around the teeth by the mucosal tissue. The host responds to this infection by the development of both inflammatory and immune responses to the specific organisms in the plaque. Both the supragingival and subgingival plaques have characteristics of a biofilm.

The initial host response is confined to the soft tissues (gingivitis). Virtually all adults demonstrate some degree of gingivitis. In a smaller number of patients the intensity of the host response leads to loss of soft tissue, the periodontal ligament which connects the tooth root to the alveolus and the alveolar bone surrounding the teeth (Fig. 2.2). When this occurs periodontitis is present. Clinical signs of periodontitis include erythema and edema of the gingival tissues, pocket formation, exposure of the root portion of the tooth, tooth mobility, abscess formation and eventually tooth loss.

A new classification of the periodontal diseases was proposed in 1999 (Armitage 1999). The two major types of periodontitis include chronic periodontitis, a more slowly progressive process that usually correlates with local etiology, and aggressive periodontitis, a more advanced form that may also occur in children and adolescents.

The natural history of periodontitis has been the subject of interest in the 1980s and 1990s. Similar to many chronic diseases, periodontitis is believed to have periods of exacerbation and remission, but with the exception of acute periodontal



Fig. 2.2 Radiograph illustrating alveolar bone loss associated with chronic periodontitis. For these maxillary posterior teeth, the alveolar crest should be just apical to the crown of the teeth (the lower arrow). The bone loss on the distal surface of the first molar tooth is indicated by the distance between the two arrows. Large calculus deposits are present on all root surfaces

conditions, repair/regeneration of lost tissue is not normally a significant part of that natural history. Therefore, periodontal disease can be considered cumulative and, with retention of teeth (Fig. 2.2), periodontal disease will be more severe in older populations.

A general review of periodontal disease affecting older adults was published in 1998 (Locker et al. 1998). They found that the available literature at that time had a number of deficiencies, which include the lack of agreement on what constitutes periodontitis, as well as the definition of ‘advanced’ or ‘severe’ periodontitis, the definition of ‘elderly’ or ‘older adult’ and the definition of the primary clinical parameter (probing depth, clinical attachment loss or alveolar bone loss). Nevertheless, Locker et al. (1998) drew a number of conclusions:

1. Evidence of moderate periodontitis is commonly found in a majority of elderly adults. While advanced periodontitis (as assessed by clinical attachment loss or bone loss) is seen in a smaller portion of the population, older subjects demonstrate the highest rate of advanced disease. These authors conclude that approximately 70% of older adults demonstrate evidence of advanced periodontitis, but the number of affected sites/teeth is small.
2. As many as three in four older adults will demonstrate additional loss of attachment when monitored longitudinally over a few years. This progression is not, in general, widespread through the mouth.
3. When monitored longitudinally, patients tend to demonstrate progression of periodontal disease in newly affected sites as opposed to continued loss at previously affected sites.
4. The most important risk factors for periodontal disease include cigarette smoking and the presence of specific periodontal pathogens. In regard to the microbiota associated with periodontal disease, Mombelli (1998) stated that the recognized periodontal pathogen *Porphyromonas gingivalis* assumes greater importance with increasing age; the importance of the pathogen *Prevotella intermedia* is relatively constant throughout the life course, while the importance of *Actinobacillus actinomycetemcomitans* decreases with age, but this pathogen may be important in related cases of ‘refractory’ periodontitis, even in older adults.

No discussion of the risk for periodontal disease in older adults would be complete without mention of age-associated changes in the inflammatory and immune responses to periodontal pathogens. McArthur (1998) asserts that there are no specific defects in the immune response that could account for periodontitis in older adults. Nevertheless, changes in the immune response with aging do occur (immunosenescence) and further research is needed as the population ages and a larger percentage of the population lives into their seventh, eighth and ninth decades.

It is important to emphasize that loss of periodontal attachment and loss of alveolar bone are not an inevitable consequence of aging (Papapanou et al. 1991; Papapanou & Lindhe 1992). In their studies of more than 500 adults in Japan and Sweden, a subset of older adults maintained an essentially intact periodontium into their seventh and eighth decades of life.

Prevalence and Incidence

A review of data from the Third NHANES (1988–1994) defined periodontal disease as having at least one tooth site with 2 mm, 4 mm or 6 mm of attachment loss (Surgeon General's Report 2000b). Examining the most severe case definition, the percent of population with periodontitis increased from 0.2% at the age of 18–24, up to 23.4% at 65–74 and 29.5% for individuals who were 75 and older. At this case definition, the percent of males with periodontitis was greater than the percent of females. A recent report of older adults in Iowa (mean age of 85 years) indicated that for those individuals with teeth, 45% had at least one site with attachment loss of 6 mm or more and 15% had at least 1 site with 8 mm or more of attachment loss. For the entire cohort ($n = 449$), 26% were edentulous (Levy et al. 2003).

Similar studies have been conducted in other countries. A study of the periodontal status and the need for periodontal treatment has been reported for persons 76–86 years of age in Finland. A total of 364 individuals were examined and 46.2% were edentulous. Of the 175 dentate individuals, the mean number of teeth was 15.1 for men and 14.0 for women. Using the Community Periodontal Index of Treatment Needs (CPITN), 11% of the subjects had one or more sites with a probing depth of 6 mm or more (CPITN = 4). The majority of teeth that were missing were molars (Ajwani et al. 2001).

Findings from other developed countries indicate a high prevalence of periodontitis in older adults. The Study of the Health in Pomerania reported on the periodontal status of individuals in Germany who were 60 years of age and older (Mack et al. 2004). Edentulism increased from 16% of individuals who were 60–65 years of age to 30% in those who were 75–79 years of age. They used two definitions of periodontitis: the presence of one or more tooth sites with a probing depth of 4 mm and greater and one or more sites 6 mm and greater. For those 60–69, the prevalence of individuals with at least one site of 4 mm and greater was 85% for males and 71% for females. Using the 6 mm criteria, the prevalence was 44% and 24% for males and females, respectively. For the older adults, 71% of males and 62% of females had at least one site of 4 mm and greater, and 32% of males and 29% of females had at least one site of 6 mm and greater.

Holm-Pedersen and colleagues (2006) from Sweden reported on the periodontal status of community-dwelling individuals who were at least 80 years of age. There were a total of 159 participants, and 30 (19%) were edentulous. Of the remaining 129 subjects, 121 received a periodontal examination. The average number of teeth present was 16.3. The criteria for 'serious' periodontitis were at least four sites with clinical attachment loss of at least 5 mm, with at least one site having a probing depth of 4 mm or more. With that case definition, 50.5% of the population demonstrated severe periodontitis.

As seen for dental caries, the periodontal status of older adults who are institutionalized (in long-term care facilities) tends to be poor, and worse than what is observed for community-dwelling seniors. Lo et al. (2004) examined a large group (3153 individuals) of institutionalized older adults in Hong Kong. The mean age was 79.8 years, and about one-fifth were edentulous. Of the dentate subjects, about

one-fifth had severe periodontitis. They also noted that approximately two-thirds reported difficulty chewing.

Longitudinal studies of the progression of periodontal disease have been reported. In a group of healthy older adults in Japan, Hirotsu and colleagues (2002) reported on the progression of periodontal disease over a 2-year period. There were 599 seventy-year olds and 162 eighty-year-old participants at the first examination, and 436 of the younger age group returned for the second examination. In general, periodontal disease in the 70-year-old cohort was pronounced; 47.3% had at least one site with 7 mm or more of clinical attachment loss. Progression of periodontal disease, defined as loss of 3 mm or more of clinical attachment loss, was seen in 75.1% of the participants who reported for the second examination. In contrast, Ajwani and Ainamo (2001) reported on the progression of periodontitis in a group of very old adults (81–91 years old). There were 57 individuals who were seen both at baseline and 5 years later. In this group, the mean number of teeth had decreased from 15.9 to 15.1. In general, there was little change in the periodontal status of these individuals. The authors concluded that periodontal disease is not a consequence of aging. However, considering the overwhelming evidence regarding the prevalence of periodontitis observed in older adults, this small sample may represent a healthy subset of individuals who are resistant to periodontal disease.

As reviewed by Alvares and Johnson (2003) age-related changes in the periodontal tissues have been a subject of interest and investigation. Minor changes in the behavior of keratinocytes in tissue culture from older individuals have been reported (reduced cell division, reduced production of interleukin 1 β). Similar differences in gingival fibroblast function in vitro have been demonstrated when comparing cells from younger and older donors. Cells from older adult donors demonstrated reduced protein production, including the vital structural protein, collagen. The conclusion is that periodontal disease is not primarily the result of aging, but may be influenced by changes in cell biology as individuals age. The etiology of periodontal disease in the elderly is considered to be the same as for younger adults, specifically an exuberant host inflammatory/immune response to the subgingival microflora.

In that regard, experimental gingivitis is a model to test the development of clinical inflammation as dental plaque is allowed to accumulate over the course of a few weeks. Fransson et al. (1996) studied the development of gingival inflammation in younger (20–25 years of age) and older (65–80 years of age) adults. All participants had a healthy periodontium at the initiation of the trial and, after 3 weeks of no oral hygiene, the older adults demonstrated a more pronounced clinical and histologic inflammatory response. A subsequent analysis revealed that the older patients had higher levels of both α -2-macroglobin and IgG3 than the younger adults (Fransson et al. 1999). Further, at the conclusion of the experimental period, there was a greater inflammatory cell infiltrate observed in gingival biopsy specimens from the older adults. Confirmatory evidence was provided by Tsalikis et al. (2002). Utilizing the 3-week experimental gingivitis model, as compared to younger adults, older adults demonstrated a significantly greater increase in the gingival fluid levels of the proinflammatory cytokine interleukin 1 β .

Determinants and Etiology

Periodontitis is a chronic disorder and is recognized as having a complex etiology and multiple risk factors. As such, these disorders meet the criteria of a 'complex' disease (Rees 2002). While specific microbial pathogens have been associated with periodontitis, the host inflammatory and immune responses are now believed to play a major role in the progression of periodontitis. Further, a variety of other local, systemic, behavioral and social risk factors for periodontitis have been identified in adult populations.

What is quite clear is that the prevalence of periodontitis increases with age (Albandar 2005). A study by Dye and Selwitz (2005) examined the relationship between a number of different periodontitis severity indices and risk factors for periodontitis. Using data from the Third NHANES, the presence of periodontitis was defined by different criteria using the attachment loss extent index (based on the percent of sites with ≥ 2 mm of clinical attachment loss), attachment loss (mean attachment loss), derived community periodontal index (based on bleeding, the presence of calculus and probing depth of ≥ 4 mm) and the periodontal status measure (which classifies patients as healthy, gingivitis or mild, moderate or severe periodontitis based on bleeding, probing depth, clinical attachment loss and furcation involvement). Data were available from more than 11,000 dentate (> 5 teeth) individuals who received a dental examination and were over 20 years old. For this analysis, age was stratified as 20–39 years, 40–59 years and 60–79 years. For all periodontal indices, older age (≥ 40 years), lower level of education, a history of cigarette smoking, male gender and being a non-Hispanic black were associated with increased severity of periodontitis. This study also identified an interesting interaction between aging and smoking; these two risk factors appeared to act synergistically to increase the risk for periodontitis when measured by clinical attachment loss.

A large body of evidence has been published that indicates that in addition to the systemic disorders attributable to smoking (lung cancer, oral and pharyngeal cancer, cardiovascular and cerebrovascular diseases), the contribution of smoking to periodontitis is enormous. Tomar and Asma (2000) used the Third NHANES database to estimate the number of cases of periodontitis attributable to smoking. They determined that 9.2% of dentate adults met their criteria for periodontitis, and in a fully adjusted model, smoking was associated with an almost fourfold increase in the odds of periodontitis. They determined that nearly 42% of cases of periodontitis in the U.S. population were attributable to currently smoking cigarettes and about 11% of cases were attributable to a history of smoking.

A study of risk factors for periodontitis in a population of older adults from Thailand examined 2005 individuals who ranged in age from 50 to 73 (Torrunguang et al. 2005a). Detailed demographic, medical and dental variables were assessed cross-sectionally. All subjects were classified as having mild, moderate or severe periodontitis based on mean clinical attachment level. Multivariate logistic regression was used to determine the strength of the relationship between different independent variables and periodontitis. In a fully adjusted model, the odds

of having severe periodontitis (≥ 4.0 mm of clinical attachment loss) were significantly associated with being 60 years of age or older (OR = 1.6), having diabetes mellitus (OR = 1.6), being a former smoker (OR = 1.7), being a current smoker (OR = 4.4), having 40%–79% plaque-infected surfaces (OR = 3.5), having 80%–100% plaque-infected surfaces (OR = 17.9) and being male (OR = 3.3). Having more than a high school education had an inverse relationship with periodontitis (OR = 0.4). Other potential risk factors for periodontitis such as income, alcohol consumption and obesity were not related to moderate or severe periodontitis.

In another study by the same authors (Torrunguang et al. 2005b) the effect of smoking on periodontitis was investigated. In this group of individuals, 48.7% were non-smokers, 36.9% were former smokers and 14.4% were current smokers. Smokers demonstrated greater supragingival plaque deposits and greater mean probing depth and mean clinical attachment loss than newer smokers or former smokers. Of particular interest, quitting smoking tended to reduce the odds for severe periodontitis.

Diabetes mellitus is a recognized risk factor for periodontitis. As noted in Torrunguang et al. (2005a) persons with diabetes were 1.6 times more likely to have severe periodontitis. A recent meta-analysis of the relationship between periodontitis and diabetes (Khader et al. 2006) indicated that compared to non-diabetics, having diabetes was associated with greater severity but comparable extent of the disease. This analysis included patients of all ages. Khader et al. (2006) noted that they were unable to examine the importance of specific variables, including age, on this relationship. This was due to a lack of specific reporting of variables including age in the original publications.

In summary, cigarette smoking and having diabetes mellitus are the most important environmental determinant and systemic disease, respectively, for periodontitis. These risk factors for periodontitis are observed across all age groups, including older populations.

Oral and Pharyngeal Cancer

Overview, Prevalence and Incidence

In the broadest context, oral and pharyngeal cancers comprise a variety of malignant disorders affecting the cells and tissues in this anatomical region. Nevertheless, discussion of oral and pharyngeal cancer generally refers to carcinoma of the oral cavity and pharynx, and specifically squamous cell carcinoma. As reviewed by Epstein (2003), oral and pharyngeal squamous cell carcinoma is a disease of adults, and older adults in particular. Virtually all cases (95%) are present in individuals 40 years or older, and the average age of diagnosis is 60–65 years of age (Surgeon General's Report 2000). The data indicate that for the United States, oral and pharyngeal cancer is the fourth most common cancer affecting black males and seventh most common cancer affecting white males. In the oral cavity, oral

cancer primarily affects the tongue, lip and floor of the mouth (Rhodus 2007). Other areas (i.e., palate and gingiva) are affected, but less commonly. In the United States in 2004, the number of patients diagnosed with oral cancer was estimated to be 28,260. In that year, there were an estimated 7230 deaths from oral cancer (Jemal et al. 2004). It is important to note that differences exist in different countries. For example, in India, after the tongue, the buccal mucosa is the second most common site for development of oral cancer (Lin et al. 2005). This appears to be related to the placement of betel leaves and areca nuts in the cheek area ('betel nut').

Determinants and Etiology

When reviewing the incidence of oral cancer, discussion of the primary risk factors is particularly important. A variety of epidemiologic and animal studies have clearly identified tobacco smoking and alcohol consumption as the two most important risk factors for oral cancer.

While cigarette smoking has been firmly established as a risk factor for oral squamous cell carcinoma (Forastiere et al. 2001), other types of tobacco use including cigar and pipe smoking have also been associated with an increased risk of oral cancer (Garrote et al. 2001). Further, the use of chewing tobacco has more recently been identified as a risk factor (Warnakulasuriya 2004). There are many variations of this product throughout the world, including the combination of tobacco and betel leaves used in Asia (Znaor et al. 2003).

Alcohol consumption is the other major risk factor for oral cancer (Mashberg et al. 1981). While the risk for oral cancer has been associated with the use of spirits, beer and alcohol, a number of studies have suggested that differences occur in the risk with different types of alcohol. In some studies beer and wine have been associated with only moderate effects on oral cancer as compared to consumption of spirits (Huang et al. 2003). Recently, a study from Spain determined that for equal amounts of consumption, use of black tobacco (pipe smoking, cigar smoking) and spirits were associated with a two to fourfold high risk of oral cancer than the use of blond tobacco (cigarette smoking) and wine and beer consumption (Castellsague et al. 2004). This study further emphasized the synergistic effects of alcohol and tobacco use on the development of oral cancer.

Another important risk factor for oral cancer is the use of betel leaves, which is often chewed in combination with areca nuts ('betel nut'). Popular in Asia, the association of betel and areca and oral cancer has been documented in studies published since the 1960s. Recent studies continue to emphasize this linkage. A report from Taiwan indicated that more than 85% of the occurrence of oral cancer could be explained by the use of betel nut (Lin et al. 2005). In another study from Taiwan (Yang et al. 2005), a group of aboriginal patients were followed for 6 years, and the development of oral squamous cell carcinoma and oral precancerous lesions were closely related to the chewing of betel nut.

It has also been observed that certain demographic variables are associated with increased risk for oral cancer. It has long been recognized that being male has

been associated with an increased risk for oral squamous cell carcinoma. Morse and Kerr (2006) examined the data from the Surveillance, Epidemiology and End Results (SEER) database. Examining data from 1975 to 2002, both the age-adjusted incidence rates and age-adjusted mortality rates were higher for black males versus white males and were lower and equal for black and white females. The survival rates at 5 years were also higher for whites with oral cancer than blacks, being the lowest for black males. An interesting study on the gender ratio of individuals with oral cancer was reported by Brandizzi and colleagues (2005). Analyzing data from Buenos Aires, Argentina, from 1950 to 2000, they observed a gradual decline in the male-predominant occurrence. From 1950 to 1970, the ratio was 7.1:1 male to female. From 1961 to 1968 the ratio was 4.3:1 and then 2.3:1 for the interval from 1972 to 1984. The most recent data (1992–2000) showed that the ratio had fallen dramatically to 1.24:1. This shift is likely due to increased exposure in women of the primary risk factors of tobacco use and alcohol consumption.

Recent research has begun to focus on genetic risk factors for oral squamous cell carcinoma. Genes controlling matrix metalloproteinase-1 promoter (Cao and Li 2006), CYP 17 (Chen et al. 2005) and epidermal growth factor receptor (Kang et al. 2005) have been implicated as risk factors. These studies have shown a positive association of the gene or specific allele with the development of oral cancer, but this research is still preliminary.

Lastly, viruses have been associated with cancer development, and while no studies have specifically linked viral infection to the risk for oral cancer, Rhodus (2007) notes that several viruses with oncogenic potential can infect the oral tissues. In particular, the human papilloma viruses (HPV), which have been shown to be important risk factors for cervical cancer, are considered potential risk factors for oral squamous cell carcinoma (Miller and Johnstone 2001). While there are many HPV genotypes, a limited number of these have been associated with dysplastic and malignant squamous cell lesions (Furrer et al. 2006). In particular, HPV16 and 18 were found in a much greater percentage of lesion scrapings (100%) versus normal tissue (9%). A recent review of infection with the human papilloma virus as a risk factor for oral cancer suggested that there may be two distinct pathways that account for cancer development: one in which tobacco and alcohol are causative, while in the other HPV infection is causative. Still, these authors state that molecular mechanisms to account for HPV-associated oral cancer are not defined. Nevertheless, this work raises the question of immunization against the HPV16 and HPV18 as a strategy to reduce the occurrence of oral squamous cell carcinoma (Ragin et al. 2007).

In contrast, a number of studies have indicated that the consumption of fruits and vegetables is associated with a reduced risk for oral squamous cell carcinoma. A meta-analysis by Pavia and co-authors (2006) examined 16 studies. Both fruit consumption and vegetable consumption were associated with a significantly reduced risk of oral cancer ($OR = 0.51$, $95\% CI = 0.40 - 0.65$, and $OR = 0.50$, $95\% CI = 0.38 - 0.65$, respectively). Both the number of portions of fruits and vegetables consumed each day and the types of fruit consumed had an impact on the magnitude of the reduced risk.

Table 2.2 Trends in 5-year relative survival rates (in percent) for cancer of the oral cavity. For comparison, data for cancer of the colon and larynx are provided

	White			African-American		
	1974–1976	1983–1985	1992–1999	1974–1976	1983–1985	1992–1999
Oral cavity	55	55	60*	36	35	36
Larynx	66	69	67	60	55	53
Colon	51	58	65*	46	49	53*

*Difference between 1974–1976 and 1992–1999 is significant at $p < 0.05$

Adapted from Jemal et al. (2004)

To further extend the relationship of diet to the risk for oral squamous cell cancer, Suzuki et al. (2006) examined the effect of consumption of antioxidants on the risk of oral cancer development in individuals who smoke cigarettes and drink alcohol. Examining 385 patients with oral, pharyngeal and laryngeal cancer and 1925 cancer-free, age- and gender-matched controls, there was an inverse relationship between intake of antioxidants (which included vitamins C, E and carotene) and the risk for oral, pharyngeal and laryngeal cancer. This effect was seen for both men and women and was present for those that smoked cigarettes, drank alcohol and both smoked and drank alcohol.

Trends in the 5-year survival rates of oral cancer are disturbing. As reported by Jemal and colleagues (2004), the survival rate for whites has increased slightly, from 55% in 1974–1976 to 60% in 1992–1999. In contrast, the 5-year survival rate for African-Americans has not changed during this 25-year interval and is significantly below that of whites (see Table 2.2). The same trends are seen when the data for 1992–1999 are analyzed by stage at diagnosis (localized, regional or distant). For whites and African-Americans, the percent diagnosed with localized, regional or distant diseases were 37% vs. 19%, 46% vs. 57% and 9% vs. 15%, respectively. Further, the survival rates differ by race. For localized disease, the survival rates for whites and African-Americans were 83% and 69%, respectively. When examining regional and distant disease, these percentages are 50% and 31% and 27% and 22%, respectively. These data clearly indicate that many oral cancers are not detected at their earliest stages, when prolonged survival or cure is most likely, and that racial differences exist in terms of the outcome of therapy.

Oral Mucosal Lesions and Candidiasis

Caries and periodontal disease are oral disorders that are generally limited to the teeth and tissues (periodontium) in proximity to the teeth. Dysplastic lesions and oral squamous cell carcinoma are disorders of the mucosal tissues that line the oral cavity. In addition, there are a variety of other diseases and disorders that affect the mucosal surfaces that must be mentioned in a review of the oral disease burden affecting older adults.

The Third NHANES database has been analyzed for the occurrence of oral mucosal lesions (Shulman et al. 2004). A total of 17,235 individuals at least 17 years of age received an oral examination and 28% had at least one oral lesion. The chance of a lesion being present increased with age, and the chance of a lesion being present at 70 years of age was almost twice that of individuals who are less than 30 years of age (see Table 2.3). For all individuals, the most common disorders were connected to wearing dentures (8.4% of lesions) and tobacco-related lesions (4.7% of lesions). The palate was the most common location for a lesion (26%), followed by the gingiva (20%), lip (15%) and dorsum of the tongue (14%). This study did not examine the occurrence of specific lesions by age.

Other reports of the distribution of oral lesions in general populations provide some insight into the occurrence of mucosal lesions in older adults. A report by Mumcu and colleagues (2005) examined 765 residents of Istanbul, Turkey, and reported on diseases and disorders of the oral cavity other than caries and periodontal disease. The mean age of the population was 35.6 years, and 21.1% of the population were at least 65 years of age. Though no malignancies were found in this population, older individuals demonstrated the highest percentage of oral lesions, and older age was significantly predictive of the presence of certain lesions (oral pigmentation, OR = 2.2; fissured tongue, OR = 2.9; lingual varices, OR = 8.4; hairy tongue, OR = 3.6; denture stomatitis, OR = 4.5; and petechiae, OR = 25.5). Some of these lesions are considered as variations of normal and do not require treatment (i.e., oral pigmentation) while others indicate problems related to a dental prosthesis (denture stomatitis) where evaluation and treatment are needed. Another study from Turkey examined both oral mucosal lesions and risk factors associated with those lesions in 700 community-dwelling individuals who were 60 years of age and older (Dundar and Kal 2007). A total of 41% of the individuals displayed one or more oral mucosal lesions, with males demonstrating a higher prevalence as compared to females (66% vs. 36%). The most common lesions were fissured

Table 2.3 Prevalence of oral mucosal lesions in the NHANES III survey, as stratified by age

Age	Sample size	With mucosal lesion (%)	Adjusted odds ratio (CI)
17–29	4541	19.0	1.00 (–)
30–39	3244	22.6	1.17 (0.95–1.46)
40–49	2513	28.6	1.34 (1.06–1.70)
50–59	1801	36.4	1.40 (1.08–1.83)
60–69	2236	39.4	1.51 (1.14–2.01)
≥70	2900	42.6	1.92 (1.47–2.51)

Data summarized from Shulman et al. (2004). *Journal of American Dentistry Association* 135 (9), 1279–1286

tongue (9.3% of individuals), lingual varicosities (8.3%), traumatic ulcer (5.7%), denture stomatitis (5.7%) and denture-associated hyperplasia (4.9%). Risk factors for mucosal lesions included being male, the length of time a denture was worn and being either a current or former smoker.

In the United Kingdom, a report on 44,007 biopsy specimens of the oral and maxillofacial areas received over a 30-year period provides some information about the occurrence of oral mucosal lesions in the general population and infers the importance of increased risk of oral lesions with increasing age (Jones and Franklin 2006). For oral lesions, a number of them were found to have a mean age of diagnosis of 55 years and older (suggesting frequent occurrence in older adults). Of these lesions, the most common were squamous cell carcinoma ($N = 1559$), epithelial dysplasia ($N = 1280$), non-specific ulceration ($N = 919$), Sjogren's syndrome ($N = 363$) and cavernous hemangioma ($N = 308$). While these data clearly represent a skewed sample, i.e., individuals seen by a dentist, who have an oral lesion that requires a biopsy, the occurrence of certain lesions in older adults is in agreement with other studies.

Other surveys have provided supporting data on the relationship of removable dentures to the development of oral mucosal lesions. Espinoza et al. (2003) reported on a cohort of 889 older adults (65 years and older) living in Santiago, Chile. They observed that 53% of individuals had one or more oral lesions. Twenty-five percent of the cohort was edentulous, and 65% wore dentures (complete or partial). The most common lesions were denture stomatitis (22.3%), followed by irritative hyperplasia (9.4%). Logistic regression indicated that use of a denture was the only variable significantly associated with an increased odds of an oral lesion ($OR = 3.26$). When specifically examining the variables associated with denture stomatitis, being female, having plaque on the prosthesis and sleeping with the denture in place were significantly associated with lesion occurrence. These data indicate that many dentures are ill-fitting and are frequently associated with erythematous and hyperplastic tissue. A study from Spain (Garcia-Pola Vallejo et al. 2002) emphasized the importance of denture use to the appearance of oral lesions. When compared to those between the ages of 30–49 and 50–69, individuals 70 years and older presented with the highest percentage of oral lesions. Having a complete denture was associated with pseudomembranous candidiasis, stomatitis and tissue hyperplasia and these lesions were most often seen in the older individuals. The relationship of denture use to oral mucosal lesions was further emphasized in another study from Brazil that evaluated adults who wore partial or complete dentures (Coelho et al. 2004). The lesions, related to both *Candida* infection and inflammatory changes, occurred most commonly in the fifth through seventh decades of life. The highest percentage of lesions was seen in association with a maxillary complete denture.

A large percent of individuals living in long-term care facilities demonstrate oral lesions (Avcu et al. 2005). Xerostomia (59%) and coated tongue (54%) were the most common problems. Another study of institutionalized older patients in France (mean age 82.1 years) revealed that 37% demonstrated candidiasis, and this fungal infection was related to lower protein intake, a vitamin C deficiency and lower serum levels of zinc (Paillaud et al. 2004).

Oral fungal infections are an important problem in the elderly, especially for those individuals who use a removal denture. Lesions classified as ‘denture stomatitis’ were observed to be fungal infections, primarily *Candida albicans* (Dar-Odeh and Shehabi 2003). While the carriage rate of *Candida albicans* is high even in healthy, dentate individuals (Kleinegger et al. 1996), individuals residing in long-term care facilities are recognized to be at increased risk for *Candida* infection (Fanello et al. 2005; Budtz-Jorgensen et al. 1996). The overgrowth of *Candida* to clinically evident infection is associated with generally mild signs and symptoms and occurs with specific perturbations of the host response or normal oral flora related to the use of inhaled steroids and systemic antibiotics (Kennedy et al. 2000).

These data clearly indicate that older adults, especially those with partial or complete dentures, are at high risk for developing oral mucosal lesions. While a variety of lesions are observed, fungal infections, generally as a result of *C. albicans* infection, are a common occurrence.

Temporomandibular Disorders

Disorders of the temporomandibular joint (TMJ) and associated anatomical structures are important problems that often prove refractory to treatment and can be the cause of significant morbidity for those that are affected. TMJ disorders (TMD) have not always been clearly defined due to a number of factors, including variability in the objective and subjective signs and symptoms, cultural and gender differences and different criteria used for disease classification.

In 1996, the National Institutes of Health sponsored a technology assessment conference on the management of temporomandibular disorders (NIH 1996). Among the conclusions from this conference are that (1) the diagnostic classification of disorders of the TMJ need to be improved and should be based on etiology vs. symptoms, (2) no consensus existed regarding treatment and (3) randomized controlled trials were needed to develop appropriate approaches to clinical care. The lack of a clearly defined diagnostic scheme has prevented a true assessment of the prevalence of TMD. Nevertheless, the prevalence in different age groups has been examined in a number of studies. Österberg and colleagues (1992) evaluated individuals who were 70 years and older. They observed a *decrease* in symptoms of TMD with aging. In a similar sense, Koidis and colleagues (1993) examined patients that ranged from 16 to 70 years of age. They demonstrated that women were affected more than men, yet symptoms of TMD decreased with increasing age.

In later studies, attempts have been made to classify TMJ disorders and to compare prevalence based on pain, with consideration of other variables including age and gender. Huang and colleagues (2002) examined patients who were classified as having myofascial pain, arthralgia or both. Among the most important risk factors for myofascial pain were clenching (OR = 4.8) and female gender (OR = 4.2). Risk factors for myofascial pain with arthralgia included somatization (anxiety associated with physical symptoms; OR = 5.0), female gender (OR = 4.7) and removal of

the third molars ($OR = 4.0$). Age was not a risk factor for any of the disease classifications.

A study has compared objective and subjective measures of TMJ disorders in younger (mean age of 27.5 years) and older (mean age of 83.4 years) subjects (Schmitter et al. 2005). Objective systems were more common in older adults; these individuals rarely complained of pain and rarely sought care for TMD from dentists and physicians. The reverse was true for the younger patients.

These data indicate that older adults are affected by TMD, but at a prevalence that is comparable to, or less than, that experienced by younger adults. Diagnosis and treatment of these disorders in older adults may be complicated by many other systemic or local disorders that affect the elderly, including cognitive impairment, musculoskeletal disorders, the number of teeth that are present and prosthetic replacement of missing teeth.

Conclusions

The three primary measures of oral health status are caries, periodontal disease and oral cancer. In addition, tooth loss is a more global measure of the oral health status of a population. Tooth loss and edentulism are a consequence of caries and periodontal disease, but teeth are removed for a variety of other reasons including lack of restorative dental services, prosthetic reasons, personal choice and lack of resources to pay for dental care. In summary, the preceding review has demonstrated that older adults bear a greater oral disease burden than other age groups.

Dental caries affecting the elderly manifest primarily as root caries (as a result of the exposure of the more vulnerable root surfaces which can occur when periodontitis is present) and recurrent caries affecting dental restorations. The loss of periodontal support for the teeth is cumulative, so when progression of disease occurs on an already compromised dentition, the consequences may be more severe. Lastly, oral cancer is a disease of older adults, with a mean age of diagnosis in the United States of 64 years.

Managing the oral disease burden is complicated by all of the considerations that accompany the care of older adults. First, the physical status of these individuals will vary from those who are community dwelling and capable of caring for their own needs to those who are institutionalized and require help with even the most basic of personal needs, including daily oral health care. The care of older adults is also complicated by illness and the use of medications that can affect the patient's ability to tolerate routine dental care or may have specific adverse effects on the oral cavity such as medication-induced xerostomia. Second, there are important social and structural barriers that limit access to care, including well-recognized risk factors for oral disease such as race, fewer years of education and socioeconomic status (See Chapter 3). In addition, Medicare does not provide benefits for routine and outpatient dental services (www.medicare.gov/coverage) and only 15% of older adults have private dental insurance (Wall and Brown 2003). In addition, benefits

provided by these plans often have a limit on the amount of coverage that does not allow for comprehensive dental care. Third, the consequences of untreated oral disease are serious and include severe morbidity and mortality associated with oral cancer; the potential of long-standing, untreated oral disease (primarily periodontitis) contributing to the risk for a number of systemic disorders affecting the elderly including cardiovascular/cerebrovascular diseases; and the effects of tooth loss on mastication and nutritional intake, self-image and comfort with social interactions.

The irony of this situation is that the dental profession and dental care services have advanced in the past two decades to offer new and successful approaches for managing dental diseases and tooth loss. The lack of a coordinated plan to address the oral health care needs of older adults is a great challenge in the United States and in many countries throughout the world (Petersen and Ueda 2006). While solutions can be offered (Lamster 2004), it will take a coordinated effort by government agencies and the profession (including local, state and national professional organizations and dental schools) to provide dental care to the large numbers of older adults who will require these services. Further, these services must be provided by an oral health care workforce that understands the specific needs of older adults. These are daunting challenges at a time when the medical and social needs of the expanding population of older adults will strain the health care system in the United States and other countries.

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