

ABSTRACT

The purpose of this report is to review the interrelationship between poor oral health conditions of older people and general health. The impact of poor oral health on quality of life (QOL) is analyzed, and the implications for public health intervention and oral health care are discussed. Findings from the current research may lead to the following conclusions: The available scientific evidence is particularly strong for a direct relationship between diabetes and periodontal disease; the direct relationship between periodontal disease and cardiovascular disease is less convincing. General and associated oral health conditions have a direct influence on elder people's QOL and lifestyle. The growing number of elderly people challenges health authorities in most countries. The evidence on oral health-general health relationships is particularly important to WHO in its effort to strengthen integrated oral health promotion and disease prevention around the globe.

KEY WORDS: oral health, general health, quality of life, geriatrics

Oral health, general health, and quality of life in older people

Daniel Kandelman,^{1*} Poul Erik Petersen,² Hiroshi Ueda³

¹Professor, Faculty of Dental Medicine, University of Montreal, Montreal, Canada; ²Professor, School of Dentistry, University of Copenhagen, Copenhagen, Denmark, and Chief, Global Oral Health Programme, World Health Organization, Geneva, Switzerland; ³Health and Ageing Societies Programme, WHO Kobe Centre, Kobe, Japan.

*Corresponding author e-mail: dkandelman@videotron.ca

Spec Care Dentist 28(6): 224-236, 2008

The global demographic transition

The global population is increasing at an annual rate of 1.2%, while the population of those 65 years or older is increasing at a rate of 2.3%.¹ About 600 million people are currently aged 60 years or older, and this number is expected to double up by 2025.² By 2050, there will be 2 billion older people, 80% of them living in developing countries. The United Nations estimates that persons older than 80 years will comprise 20% of the world population.³ In China, approximately 10% of the total population are 60 years or older; this proportion is expected to increase in the next decades, and a significant proportion of the older population will live in rural areas. In India, the percentage growth of the population aged 60 years or older is much higher than that of other age groups. Life expectancy at birth was only 32 years when the country achieved its independence 50 years ago, whereas the current figure has risen to more than 62 years. In the United States, the age group showing the greatest increase in numbers is the centenarians (people aged 100 years and over). In Japan, the ageing population is changing rapidly, with the proportion of adults 65 years or older at 17.2% in 2000 growing to 28.9% in 2025.¹

The growing proportion of the elderly is attributed mainly to the decrease in mortality rates among older people and overall decline in birth rates. In addition, progress in health care and the implementation of public health measures have extended life expectancies worldwide. The demographic transition challenges health authorities, particularly with regard to the growing burden of disease and its negative impact on quality of life (QOL) of older persons. The burden of disease also includes poor mental health. For instance, a Swedish study⁴ showed that the total number of people suffering from physical and mental disorders is increasing and becoming more difficult to treat. Poor oral health also

affects people's QOL of life with respect to impaired eating, social appearance, and communication.⁵ The rise in life expectancy without improvement in QOL has a direct impact on health expenditures and is becoming a key public health issue in the more developed countries.^{5,6} It may also become a major burden to countries with high population densities and emerging economies, such as China and India.

The WHO Health Report 2002² identified some major global risks of disease, disability, and death in the world today. The impact of different risks of losing healthy life years is aggravated with ageing because of lower individual resistance, the growing burden of chronic

diseases, and poor socioenvironmental and nutritional conditions. Although most persons can now look forward to living longer, the risk of developing at least one chronic disease (such as hypertension or diabetes) increases with age; this reflects more of a cumulative effect of a lifelong exposure to risk factors and is not related to chronological age *per se*.² The World Oral Health Report 2003⁷ emphasizes that oral diseases are age related, that the risk factors for chronic disease are common to most oral diseases, and that oral health is an integral part of general health and an important component of QOL. Chronic diseases are more prevalent in the older population, whose age-associated physiological changes may deprive them of their mobility and independence.²

For the 21st century, the challenge to control chronic disease and improve oral health and general health can only be tackled effectively through shared approaches and with a focus on common risk factors. In order to address these issues in public health programs, it is important to ascertain to what extent oral health is linked to general health. The association between oral and general health may be more apparent in old age. The purpose of this report is to review the literature on the interrelationships between poor oral health conditions of older people and general health. The impact of poor oral health on QOL is analyzed and the implications for public health intervention and oral health care are discussed. The evidence on oral health-general health relationships is particularly important to WHO in its efforts to strengthen integrated oral health promotion and disease prevention around the globe.

Psychosocial function, general health, and oral health

Many physiological changes take place as part of aging, such as decreasing vigor, as the general metabolism slows down. Hearing and sight, smell, and taste may

be impaired to some degree.⁸ The general body physiology is affected, along with organ functions, including reduction in heart strength, reduction of ventilatory capacity of the lungs, slower nerve transmission in the brain, decreased muscle mass, and increased risk of endocrine problems.⁸ Activities involving locomotion may also be impaired due to loss of elasticity in supporting structures.⁹ Changes in oral function remain minor as long as oral health status is preserved; however, the situation can be quickly compromised if oral health is not maintained.⁸

In an attempt to identify target groups for which oral health care can be rendered, older people may be classified into three categories according to psychosocial function:¹⁰

1. The functionally independent older adult
2. The frail older adult
3. The functionally dependent older adult

Individuals in the first group can remain largely independent even if they have some chronic diseases that need ongoing health care. Individuals in the next two groups need assistance in maintaining the most basic levels of personal care. The third group includes those individuals requiring special care at home or in institutions. In most developing countries, family and social support structures are eroding due to a variety of factors, and frail older individuals are consequently at high disease risk.¹¹ In older persons, socioeconomic factors such as low income, low education, and weak social support are shown to be closely related to functional impairment in oral health.¹²⁻¹⁴ Petersen and Nörtov¹³ found that inactive lifestyles and weak family networks are highly associated with poor oral and general health and dental care habits among old-age pensioners. Recent studies^{9,14-17} have indicated a direct relationship between reduced functional capacities and poorer personal oral hygiene as well as declining use of dental services.

Mental health

Mental illness is particularly problematic in the elderly population due to the

increased prevalence of dementia with increasing age.¹⁸ Dementia may affect the individual's ability to perform appropriate oral hygiene procedures, and a few studies¹⁹⁻²⁷ have been conducted to ascertain if dementia would have a negative effect on the oral health of older people. A study assessing the oral health of psychiatric elderly in-patients in South Wales¹⁹ demonstrated a higher prevalence of edentulism than in the general population of the respective age group, as well as relatively poor oral hygiene and a higher score of dental caries experience. This confirms previous findings from a similar study in Denmark.²⁰ Periodontitis is a problem in older adults, and psychosocial stress may induce neglect of oral hygiene and poor periodontal health.²¹ Furthermore, resistance to periodontal therapy has been reported in people suffering from psychosocial problems.²² Persson *et al.*²³ reported that depression was not associated with a greater risk of periodontitis in older adults but was associated with tooth loss and pain related to chronic disease conditions. Poor mental health status was considered as a risk factor in a six-year prospective cohort study of tooth loss and edentulism among institutionalised elderly people.²⁴

Dementia and particularly Alzheimer's disease are frequently seen in older people, and the prevalence rates increase with age.^{18,25} The progressive loss of intellectual function and memory inevitably leads to deterioration in oral health unless the family or institution are able to assist in oral health care. A study²⁶ assessing the oral health of individuals with dementia in nursing homes reported that moderate-to-severe dementia may have a deleterious effect on the oral health of residents. Chalmers *et al.*²⁷ reported in a study of community-dwelling older adults that participants with dementia had a significantly higher experience of oral disease and related conditions compared with participants without dementia.

A recent study²⁸ of patients with Parkinson's disease (PD) analyzed data on oral health conditions and related factors in people aged 60-69 and 70+ years.

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

It was reported that patients with PD often complained of chewing difficulties as many were edentulous or had swollen gums. Almost half of the patients did not brush their teeth or clean their dentures properly. Complaints about chewing difficulties were most frequent among patients with PD who had dyskinesia and oral dyskinesia. In addition, problems related to poor function of dentures (i.e., loosening or poor retention of denture) were related to lack of muscle coordination and rigid facial muscles. Patients with PD also appeared to have a high risk of losing their teeth because of the use of anticholinergics or monoamine oxidase inhibitors and poor oral health due to xerostomia. Dysphagia is known to be a common symptom in many patients with PD²⁹ and may result in aspiration pneumonia, especially when oral hygiene is neglected.²⁸ Daily tooth-brushing and cleaning of dentures may be impaired due to resting tremors, akinesia, and bradykinesia.²⁸

Visual impairments

Visual impairments can be included among chronic disease conditions associated with poor oral health in old age. The main age-related impairments are cataract, macular degeneration, retinal detachment, and glaucoma. Blindness is also linked with diabetes retinopathy, trachoma, and leprosy.³⁰ Although the pattern of oral disease in persons with disabilities is shown to be similar to their peers without disabilities,³¹ visual impairment can affect an elderly person's ability to maintain oral health and recognize signs of oral disease such as dental caries or gingival bleeding.

Xerostomic conditions

Xerostomia, the subjective experience of oral dryness, is quite prevalent in older people as roughly 30% of individuals have reported that they are affected by dry mouth.³²⁻³⁵ Xerostomia is usually associated with a decreased salivary flow rate (hyposalivation) as well as some psychological factors, but may not necessarily be related to a decreased salivary rate.³³ Traditionally, it was believed that salivary function decreased because of

aging.³⁷ In healthy adults, age-associated changes in salivary composition and flow are minimal.³³ Salivary gland hypofunction (SGH), which is a change in quality and/or quantity of saliva, may be due to the effect of systemic diseases such as diabetes, Sjögren's syndrome, AIDS, or their treatment. Head and neck radiation or multiple use of medications can cause SGH.³²⁻³⁷ One review listed more than 400 medications implicated in causing xerostomia, the most common being antidepressants, antipsychotics, anticholinergics, and antihistamines.³⁸

It is evident that consumption of multiple medications remains an important etiological factor in dry mouth.^{37,38-40} The impact of the duration of exposure to medication on salivary hypofunction in unhealthy older people is largely untested,⁴⁰ as are the subjective complaints of dry mouth when there is a decrease of salivary flow.³⁹

QOL can be compromised by dry mouth as the condition affects mastication, swallowing, and speech.^{41,42} Recent studies have confirmed that dry mouth had a significant and negative impact on the QOL of elderly individuals.⁴³⁻⁴⁵ Reduced salivary flow may disturb the normal protective mechanisms for the teeth and mucosa. Persons affected are more likely to have oral symptoms such as sensory changes. It appears that some older adults have xerostomia, some have salivary gland hypofunction, some have both conditions, and some have none. Therefore, management of patients affected by xerostomia can be difficult.

Nutrition and oral health

The relationships between oral health status, dietary practices, nutritional status, and general health status are complex.^{46,47} Inadequate nutrition affects oral health,⁴⁸ and poor oral health affects food choices. A diet deficient in vitamins, minerals, proteins, and calories can impair the immune system,⁴⁹ and for this reason, diet and nutrition are related to oral health, specifically, to oral cancer and dental diseases in older persons.⁵⁰ Lack of appetite among the elderly is common, especially in individuals suffering from anorexia, nausea, vomiting, or

xerostomia resulting from medication. Food intake is reduced even more among individuals with chronic diseases. A Swiss study of elderly hospitalized patients⁵¹ observed the relationship between clinical parameters of malnutrition, serum albumin level, and indicators related to oral health (dental status, oral hygiene, masticatory function, and salivary secretion rate).

A Florida dental care study,⁵² which assessed the dietary implications of oral health among African-American and white older adults, provided evidence that poor oral health and the accompanying functional disability impacted on day-to-day living. Chewing, taste perception, swallowing, and comfort with dentures have been reported^{50,51} to be the leading causes of poor nutritional status in older persons. Poor general health status, dehydration, drugs, and oral dryness directly influence the appetite and diet and nutritional status of older people.⁵⁰ The importance of chewing capacity has been well established in relation to nutritional status as the number and distribution of teeth will influence the ease of chewing.^{47,53} The choice of food items becomes largely dependent on the ability to consume them with satisfaction,⁵⁴ and certain foods are rejected when they are too hard to chew. The attitude of the elderly in selecting foods is therefore strongly influenced by their ability to chew them effectively.⁵⁵ The status of the teeth and/or prosthesis is an important factor in food selection and dietary fiber consumption.⁵⁶

The third National Health and Nutritional Examination Survey (NHANES III)⁵⁷ collected information to examine associations between the number of posterior occlusal pairs of teeth and the nutritional status of older adults. The results indicated that dentate status was closely associated with nutritional status, and this suggested that the status of dentition should be considered in nutritional counseling and assessment of needs for older adults.

Chewing function in elderly persons may be compromised if there is loss of teeth and dentures age and wear without maintenance.⁵⁸ Individuals living in institutions are more like to have this

problem and require help from personnel who are adequately trained.⁵⁵

Weight loss

Studies of hospitalized and institutionalized older adults suggest a relationship between poor oral health and weight loss.^{59,60} A recent one-year follow-up study⁶¹ among adults 70 years or older identified edentulousness as an independent risk factor for weight loss. A longitudinal survey⁶² was designed to determine the association between periodontal disease and weight loss in 1,053 individuals aged 65 years and older. The study showed that the periodontal pockets of at least 6-mm probing depth were significantly associated with weight loss.

Osteoporosis

Osteoporosis is a degenerative chronic disease that affects the entire skeleton and is mainly prevalent in older women. An evaluation of cross-sectional studies have shown an association between osteoporosis and periodontal status.⁶³⁻⁶⁵ Other studies have suggested that periodontitis may be aggravated in people with osteoporosis, but failed to detect such a relationship in the early stages of osteoporosis.^{66,67}

Orofacial pain

Elderly people may be vulnerable to chronic pain because of their systemic diseases.¹² Self-reporting of chronic pain seems to increase up to but not beyond the seventh decade of life; chronic pain in older people is more often experienced from major joints, the back, legs, and feet.⁶⁸ A study⁶⁹ among Korean elders recognized that orofacial pain was an important problem in geriatric health; older people reported a higher number of disability days because of their pain than the general population.

Impact of oral disease on general health

Oral disease and respiratory diseases

Respiratory diseases are responsible for significant morbidity and mortality in

human populations.⁷⁰ The upper part of the respiratory tract is in close contact with the oral cavity through the oropharyngeal area. The oral cavity is constantly irrigated by the flow of saliva. Under normal conditions, the movement of saliva has a cleansing and protecting action on teeth and oral mucosa, and it helps to maintain a stable equilibrium between the diverse components of the oral flora. However, this equilibrium may be rapidly disturbed when poor dental hygiene favors dental plaque accumulation causing periodontal disease. This situation occurs frequently among elderly persons, especially when they lose their mobility and independence.⁷¹⁻⁷³

Recent studies⁷⁴⁻⁷⁶ have suggested an association between poor oral hygiene and respiratory infection. The relationship of poor dental health and respiratory diseases has been studied in people living in nursing homes and chronic care facility institutions; these individuals are generally more at risk of contracting respiratory infections. Severe respiratory diseases include chronic obstructive pulmonary disease (COPD), chronic bronchitis, emphysema, and aspiration pneumonia. Lower respiratory infections may begin as a contamination of the lower airway epithelium by microorganisms present in aerosolized droplets or by aspiration of bacteria from oral secretions. One hypothesis is that oral bacteria may play a role in the exacerbation of COPD and aspiration pneumonia.⁷⁴ Another hypothesis is that poor oral health and COPD are linked due to common risk factors.⁷⁶

Aspiration pneumonia

Pneumonia is a disease frequently contracted by elderly people and accounts for the majority of admissions to hospitals from nursing homes. Studies⁷¹⁻⁷⁶ have shown that some of these patients were at high risk of lung infections due to virulent organisms in their oral fluids when they aspirated them. This is seen in chronic care patients whose defense mechanisms (cough reflex mainly) are diminished. Although respiratory tract infections are linked to *Streptococcus pneumoniae*, sources from the gastroin-

testinal tract and oral cavity have also been identified. Respiratory pathogens are commonly found among species of microbes present in dental plaque and periodontal pockets, and they are thought to be responsible for lower lung infections.⁷⁷ Aspiration pneumonia—an infection caused by oropharyngeal secretions, food, and/or gastric contents aspirated into the lungs—is found among debilitated older people and patients in intensive care units.⁷⁸ A relationship between aspiration pneumonia and periodontal disease has been reported in certain studies^{73,79-81} where the responsible bacterial species usually found in periodontal pockets have been observed in the lower respiratory tract. Although the list of those agents is getting longer, the identification of the critical species involved is still a matter of debate.

Patients who have swallowing difficulties (dysphagia) provide additional evidence of the importance of oral sources of bacteria in aspiration pneumonia.⁸² A study⁸³ that followed residents living in nursing homes for one year observed that inadequate oral care and difficulty in swallowing (when combined) were significant predictors of radiologically confirmed pneumonia.

Oral health conditions, dental infections, and cardiovascular diseases

Data on oral health status in older people with cardiovascular diseases (CVD) are scarce as the research interest in this relationship has been directed more toward younger adults. Some 20 years ago, attention was drawn to a relationship of dental infections with coronary heart disease and cerebral infarction alongside other independent risk factors including age, hypertension, diabetes, and smoking.⁸⁴ More recent studies have suggested an association between dental disease and CVD.^{78,85,86}

Poor oral health conditions

A relationship between poor oral health and coronary heart disease (CHD) has been reported in a few studies,⁸⁶⁻⁸⁸ in which tooth loss and moderate-to-severe periodontal disease were significantly

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

associated with coronary heart disease. Joshipura *et al.*,⁸⁹ in a six-year follow-up study of 51,529 male health professionals, found a relationship between tooth loss, periodontal disease, and CHD, and suggested that diet and infection were potential mediators of this association. Meurman *et al.*⁹⁰ investigated the oral health status and health-related behavior of 256 CHD patients referred for open-heart surgery. They observed a poorer oral health status and inadequate oral hygiene practices in the CHD patients as compared with patients who were cardiovascularly healthy. Oral disease has been suggested as an important factor in the pathogenesis of cardiovascular and cerebrovascular diseases as oral infection has been found to be a risk factor for atherogenesis and thromboembolic events.⁸⁵ However, the mechanisms involved have not yet been clarified.

Periodontal disease, missing teeth, and CVD

A state-of-the-science review⁹¹ indicated that nine studies suggest that the chronic infection inherent in periodontitis may be associated with cardiovascular events.^{84,85,87,90-97} In a cohort study,⁸⁵ bone loss and pocket depth scores in periodontal disease appeared as a risk factor in coronary heart disease and stroke. Another survey established the relationship of periodontitis with a non-invasive measure of atherosclerosis; this association indicated that periodontitis may play a role in the pathogenesis of atheroma formation.⁹¹ Periodontal conditions have also been related to carotid calcification in older persons.⁶⁵ Three studies⁹⁸⁻¹⁰⁰ however, did not support the association between periodontal disease and CHD, and the authors concluded that there was not enough evidence to state that periodontal infection was directly related to CVD. It was recommended that new studies be initiated, focusing on the periodontal disease processes and infection mechanisms. Moreover, CVD (such as coronary heart disease and ischemic stroke) should be evaluated separately, as the latter was more consistently associated with chronic infections.^{93,94} Since CVD and

oral diseases share several risk factors, these studies should be cautiously interpreted. Senescence of the immune system has been considered as a factor in periodontitis among older individuals; also, periodontal disease increases in prevalence in persons who have diseases of the immune system.¹⁰¹

From a questionnaire sent to health professionals, Joshipura *et al.*⁸⁸ reported a higher risk of CHD in people with 10 or fewer teeth than those with 25 or more teeth. Similar evidence was also obtained in a Finnish clinical study¹⁰² based on a representative sample of males aged 45–64 years. In this national health survey, the number of missing teeth proved to be an additional significant risk factor for ischemic heart disease. In a recent study, Joshipura *et al.*⁸⁹ confirmed that periodontal disease and fewer teeth may be associated with a greater risk of ischemic stroke. Matsamura *et al.*¹⁰³ assessed the cross-sectional association between dental status and blood pressure or heart rate in 499 Japanese who were 80 years old. Results following a multiple regression analysis indicated that an inverse association between the number of teeth and heart rate was statistically significant, after control of confounding factors. Based on a retrospective study from data collected from dental records and health questionnaires among 1,006 adults, Lagervall *et al.*¹⁰⁴ confirmed that CVD, diabetes, and rheumatoid disease were significantly correlated to the number of lost teeth, which may represent one aspect of periodontal disease. Loesche and Lopatin⁷⁸ have carefully assessed the interaction between oral health and medical diseases in older individuals. Missing teeth again seemed to be “uniquely associated with coronary heart disease.” Edentulous individuals appear to be at a greater risk of coronary heart disease and premature death;⁷⁸ and the possible explanations of this are complex. Two cross-sectional studies^{93,105} have suggested that dental disease may be an important risk indicator for both CVD events and acute attacks of

myocardial infarction, emphasizing the complex interrelationships existing between chronic dental infection, coronal and root caries, poor oral hygiene, periodontal disease, and tooth loss. These researchers used pantomographic information and the Total Dental Index, which takes into account the prevalence of caries, periodontal disease, missing teeth, and infections.^{93,105} Their findings suggested that the latter index appeared more important than classical risk factors such as diabetes, hypertension, smoking, or cholesterol levels.

Worldwide, dental caries and periodontal disease are major causes of tooth loss and may impact oral function. Even though tooth loss may impair functional mastication, replacement prosthesis may improve function. Some older people seem to adapt well to tooth loss and dental prostheses and partial tooth loss may not markedly change their dietary intake.¹⁰⁶

Oral health condition and diabetes

The relationship between diabetes and periodontal disease has been established in meta-analysis of data from four studies demonstrating a significant association between diabetes mellitus (type 1 and type 2) and periodontal disease.¹⁰⁷ Loe¹⁰⁸ even considered periodontal disease as the sixth complication of diabetes mellitus, and Grossi and Genco¹⁰⁹ proposed the concept of a two-way relationship between periodontal disease and diabetes mellitus. Indeed, it has been shown that the risk and severity of periodontal disease are dependent upon the diabetic patient's glycemic control. Thorstensson and Hugoson¹¹⁰ found that, among adults more than 40 years of age, long-duration insulin-dependent diabetic patients had severe periodontal disease, which increased in severity with the duration of diabetes. The evidence available suggests that, because of the senescence of the immune system and greater risk of poor oral hygiene, diabetes in old age may be a risk factor common to heart disease and periodontal disease.^{111,112}

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

Table 1. Evidence from examination of links between oral health and general health.

General health	Oral health
Mental diseases, including dementia and Parkinson disease	<ul style="list-style-type: none"> • High levels of caries experience • Tooth loss • Periodontal disease/impaired or neglected oral hygiene • Experience of pain • Chewing difficulties • Poor function of dentures
Visual impairment	<ul style="list-style-type: none"> • Dental caries • Gingival bleeding • Reduced ability to maintain oral health
Xerostomia related to systemic disease, head and neck radiations, or multiple/regular use of medications	<ul style="list-style-type: none"> • Dental caries/root caries • Candidosis • Impaired mastication, swallowing, and speech
Inadequate nutrition (impaired immune response)	<ul style="list-style-type: none"> • Periodontal disease • Tooth loss • Poor oral hygiene • Masticating function and swallowing • Taste perception • Oral dryness • Oral pain • Oral cancer
Weight loss	• Edentulousness
Respiratory diseases <ul style="list-style-type: none"> • chronic obstructive pulmonary disease • aspiration pneumonia 	<ul style="list-style-type: none"> • Poor oral hygiene • Periodontal disease • Difficulty swallowing
Cardiovascular disease <ul style="list-style-type: none"> • coronary heart disease • stroke 	<ul style="list-style-type: none"> • Tooth loss • Severe periodontal disease (bone loss, deep pockets)
Diabetes mellitus (type 1, type 2)	• Severe periodontal disease
Oral cancer	• Poor oral hygiene and health conditions
Quality of life	

Root surface caries and general health

The prevalence of root surface caries is high in older populations. A few studies have examined the possible relationship between oral health¹¹³ or general health risk predictors^{114,115} and the presence of root caries. Loesche and Lopatin⁷⁹ stated that root caries was part of the Total Dental Index, which was a good risk predictor of CVD. It is presently difficult to establish any strong relationship between root caries and specific chronic disease related to old age.

Oral cancer and precancer lesions

Cancer of the oral cavity and pharynx have markedly higher rates of morbidity and mortality when compared with other types of cancers, with an overall five-year survival rate of only about 53%.¹¹⁶ Older people have the greatest risk for the development of premalignant lesions and oral cancer; most cases occur in the age group above 60 years. The major risk factors are smoking and alcohol consumption.¹¹⁷⁻¹²²

Decline in various defense mechanisms, the presence of common risk

factors (smoking, alcohol) related to oral and general health, and lower psychological and socioeconomic status have a significant impact on cancer survival of elderly people.^{122,123} Precancerous lesions such as leukoplakia and lichen planus are frequently seen in older people, and are associated with lower socioeconomic status.¹²⁴ Sepehr *et al.*¹²⁵ in northeast Iran evaluated the association between some potential risk factors and squamous dysplasia, which is a precursor lesion of esophageal squamous cell carcinoma (ESCC). They concluded that poor oral health showed a dose-response relationship with ESCC risk and consequently could be considered as a risk factor for this type of cancer.

Oral health, general health, and QOL of older adults

The concept of QOL in health recognizes the value of an individual's health with the broader psychological and social aspects of life.¹²⁶ This model requires that healthcare providers must shift from a narrow disease focus to a broader psychosocial approach.

Conceptualizing QOL requires assessing not only factors such as discomfort or pain and oral health function such as mastication and speech, but also emotional and social functions such as appearance and self-esteem as well as perceived needs with regard to general and oral health. QOL is particularly affected by dentate status, including the use of partial and complete dentures. In recent years, research has demonstrated the impact of oral and general health on the QOL in older populations.^{13,41,58,126,127}

Pain, discomfort, mucosal infections, and xerostomic conditions related to multimедication use, as well as tooth loss, can cause a deterioration of QOL. These problems impair self-esteem, daily life, and well-being.⁴²⁻⁴⁵ Chronic dry mouth can impact essential aspects of life such as speaking, ingestion of foods, and wearing of dental prostheses.¹²⁸ Poor oral health can be related to systemic diseases in a

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

two-way relationship, and compromised chewing and eating abilities can impact nutritional status.⁴⁷ Social relationships also play an important role, as they optimize the well-being of older adults. Slade *et al.*⁴¹ described a model of social relations that helps to explain the relationship between an individual's personality, behavior, and social network, and its influence on oral health-related quality of life (OHRQOL). Petersen *et al.*¹³ established an index of lifestyle activity among old-age pensioners in a Danish community; they found a significant relationship between poor dental health conditions and lowered lifestyle activity. In addition, indices were constructed for the measurement of health support related to involvement of social networks (such as family, friends, or neighbors). This study¹³ showed that isolated older people have the lowest dental health status and make poor use of health services.

A variety of QOL instruments have been introduced for use in health care.^{127,129-133} These instruments appear to be more useful for assessment of the impact of use of health services and quantification of the effects from a patient perspective rather than from the biological or physiological perspective. Assessing OHRQOL in medically compromised elderly people, Locker *et al.*¹³⁴ found that selected health indicators were significantly associated with those measures, suggesting that oral disorders have a significant effect on the well-being and life satisfaction of older individuals. Findings from an Ontario study of the oral health of older adults suggested that self-perceived poor oral health and poor QOL co-exist in the same subgroup.¹³⁵ Gift *et al.*¹³⁶ found that the perception of general health and epidemiological indicators of oral health status are significant factors in understanding oral health behaviors and OHRQOL. MacEntee *et al.*¹³⁷ observed that three factors are usually most important for an older adult's OHRQOL assessment: lack of pain, ability to maintain proper hygiene, and a disease-free mouth.

A variety of OHRQOL measures in the elderly have been proposed in the literature.^{138,139} They assess the extent to which oral diseases and disorders affect functioning and psychosocial well-being. Their potential use in geriatric dentistry includes population applications and the use for political, theoretical, and practical reasons. Existing instruments have been mainly designed for cross-sectional rather than for longitudinal studies.³⁸ White¹⁴⁰ suggests that currently available OHRQOL instruments have limited applicability in dental clinical care settings.

A state-of-the-science conference on assessing oral health outcomes by measuring health status and QOL emphasized the need to incorporate QOL dimensions.⁴¹ However, there is a need for further research in defining the categories of OHRQOL because: (a) little experience is available from their use in long-term studies; (b) adaptation of the instruments to provide valid measures in surveys is needed (i.e., social impact of oral health conditions, perceived objective needs of the individual, and improvement of oral care services); and (c) responsiveness of many OHRQOL assessments has not been established. According to Hebling and Pereira,¹³⁹ most of the OHRQOL tools have been assessed through a validation process. Thus, comparing OHRQOL among populations, cross-cultural equivalency should be verified and the instruments must exhibit consistent findings by different researchers in different settings. Recently, WHO developed an operational measure of ORHQOL for population surveys and emphasized the need for incorporating QOL measures in evaluation of community-based oral health promotion.¹⁴¹

A few recent studies¹⁴²⁻¹⁴⁴ have suggested that implant-supported restorations¹⁴⁴ and particularly implant overdentures may improve a patient's QOL and provide better function and comfort.¹⁴² However, it is important to note that considering the high cost of these restorations, they cannot be provided for all older people, in all situations and all countries.

Impact of demographical, social, and cultural factors on dental health and on seeking dental care

Although data on oral health status are scarce, particularly in the developing countries of Africa, Asia, and Latin America, the available evidence shows oral health disparities among older people across and within countries.¹⁴⁵ These disparities mainly relate to living conditions and the availability of services for seniors, as well as the differences between rural and urban areas.

Early Canadian surveys¹⁴⁶⁻¹⁴⁸ reported differences in dental needs and oral health conditions for the home-bound, nursing home, or institutionalized older adults. At about the same time, a review of the Swedish literature¹⁴⁹ on older people's dental health reported a higher frequency of edentulousness among institutionalized elderly people than among those living at home. Slade *et al.*¹⁵⁰ observed that institutionalized older persons were more than twice as likely to be edentulous than noninstitutionalized older persons.

Socioeconomic and education levels are important determinants of oral and general health conditions.¹⁵¹ The World Health Organization International Collaborative Studies (ICS) II^{152,153} has reported on the extent of social inequality in oral health across and within countries. Epidemiological studies conducted over the past 20 years or so show that inequalities in oral health are even more pronounced among older adults.¹⁵⁴⁻¹⁶⁰ Surveys carried out in the United Kingdom,¹⁵⁴ Québec, Canada,¹⁵⁵ and Denmark⁵⁸ demonstrated that the social gradient in tooth loss and dentate status remained stable over time, and similar gradients by income, education, or social class were also observed with respect to the utilization of professional dental services. In older populations, an association between dental health behavior and dental health status has also been documented.^{16,151,154,156,157} A Japanese

survey¹⁵⁸ used the oral health impact profile (OHIP-14) to evaluate the impact of oral disease on OHRQOL in a group of independently living elderly persons in an urban area of Japan, and no significant relation was found between the measures of oral and general health and sociodemographic variables.

Previous studies^{154,159,160} have shown that dental caries experience in older adults varies by socioeconomic status, whereas the social gradient with regard to periodontal health status was weaker.^{14,161} Poor periodontal status in disadvantaged population groups was complicated by the influence of tooth loss, wearing of removable dentures, chronic systemic diseases, and high tobacco consumption.

Concluding remarks on the interrelationships between oral health and general health

The association between oral and systemic disease has been evaluated by epidemiologic and clinical studies.^{21,162,163} Several biological mechanisms have been suggested such as inflammatory mediators from oral inflammatory conditions such as gingivitis and periodontitis can enter the circulation and contribute to the burden of systemic inflammation which in turn has been associated with systemic disease. This article has attempted to outline the current evidence of the association of oral health and general health. The criteria which need to be applied for evaluating the strength of evidence include: (1) specificity (i.e., a specific agent is found to produce a specific effect); (2) strength of the association; (3) dose-response relationship; (4) time sequence; (5) biologic plausibility; (6) consistency in results; and (7) independence from confounding factors. The evidence for oral health/general health relationships is strong for the two-way association between diabetes and periodontal disease,¹⁶⁴ while that for other

relationships are more circumstantial, as they are based on cross-sectional rather than longitudinal studies.

Several chronic diseases and oral diseases relate to common risk factors such as the use of tobacco, excessive consumption of alcohol, poor diet and nutritional status, and poor oral hygiene, all of which are significantly affected by socioeconomic and environmental factors. Reports are available showing that bivariate associations between certain chronic diseases and oral disease may be due to the effect of confounding factors.^{162,163} Appropriate analyses with adequate statistical adjustment for age and tobacco use suggest that the observed associations between periodontitis and systemic disease (such as CVD) are coincidental rather than causal.¹⁶²

In summary, the research on the links between oral health and general health has focused primarily on the associations outlined in the following diagram (see Table 1).

Findings from the current research and the use of the strength-of-evidence criteria¹⁶⁵ for causal links between oral health and general health indicators have led to the following conclusions:

- The available scientific evidence is strong for a direct relationship between diabetes and periodontal disease and also suggests a relation between periodontal disease and diabetes control.
- The evidence of a direct relationship between periodontal disease and CVD and between periodontal disease and respiratory diseases is less convincing. Evidence is limited by the lack of consistency and the fact that most studies have used a cross-sectional rather than a longitudinal design or have inadequate controls for confounding factors. An appropriate analysis with adequate adjustment for age, tobacco use, and other factors suggests that observed associations between periodontitis and CVD could be coincidental rather than causal.
- The impact of xerostomia—dry mouth—on the health of the oral cavity has significant biological plausibility. One problem lies in distinguishing the effects of medica-

tions on dry mouth from those of the underlying health condition. There is good evidence that dry mouth negatively affects oral function and QOL.

- Biological and behavioural factors are implicated in the complex two-way relationships between inadequate nutrition and weight loss on the one hand and poor oral health status on the other. Diet and nutrition in old age are affected by changes in the immune system, by tooth loss and the status of the oral cavity, and by environmental factors. The evidence is strong that medications can provoke malabsorption of vitamins and minerals essential for health.
- Psychosocial factors and common risk factors may be involved in the association between poor mental health and visual impairment and poor oral health.
- Men and women may need to be examined separately since biophysiological change and experience may be gender specific.

Translating knowledge into solutions

WHO goals for better oral health for older people have not yet been adequately addressed by countries worldwide. Reducing social inequity in oral and general health as well as improving accessibility to oral health services remain the key issues, in particular for older people.^{145,166}

Promoting health of the aging population will undoubtedly require multiple actions by public health authorities, and these decisions must be based on an understanding of the determinants of health.² As the risk factors responsible for chronic systemic diseases are common to most oral diseases, the common risk factor approach may be instrumental in the planning and surveillance of oral health promotion and oral disease intervention programs.^{7,145} Health and oral health policies will also have to consider the life course perspective in order to preserve good oral and general health and maintain QOL. Finally, during

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

any knowledge transfer, it is essential that cultural values and beliefs associated with the health of populations at which these activities are aimed are observed and understood. Also, the social and family environments are particularly important when dealing with older populations.

The Ottawa Charter on Health Promotion was endorsed by WHO in 1986,¹⁶⁷ and subsequent global meetings have followed up on defining strategies for promoting health. The relevant approaches comprise policy development, legislation, community action, and organizational change. In 2005, WHO organized the so-called Bangkok meeting that focused on strengthening health promotion in a globalized world.¹⁶⁸ The Bangkok Charter identified a number of required actions for translation of the available science on promoting health. The effective use of science may be achieved when all sectors of society take appropriate actions and when promotion of health is made a core responsibility for all of national governments and health authorities. Adopting the principles of the Bangkok Charter, the Liverpool Declaration (www.who.int/oral_health) specified the actions needed for governments to undertake in order to achieve better oral health and the important target groups include older people.

In order to promote the oral health of older people, action must be taken at several levels:

- *Strengthening health promotion and integrated disease prevention*
- *Educating caregivers, older adults, and their families on oral health*
- *Educating older adults and creating healthy environments*
- *Undertaking research in public health and epidemiological research on oral health—general health links and common risk factors and QOL*
- *Capacity building within oral health systems, based on age-friendly primary health care*
- *Improving social security and health insurance coverage for older adults*
- *Monitoring oral health and evaluating community oral health programs*

Developing comprehensive policies on ageing in order to improve health and oral health of the older adults will constitute a real challenge to oral healthcare providers and particularly to the oral health profession.^{145,168} Greater attention on the part of health professionals to the oral health status of elderly people may reduce the prevalence of oral cancer in the older adult population.¹⁵³ Early detection and referral of oral cancer are critical steps that affect the success of treatment and survival rates. There is a specific concern about the situation in most developing countries where access to health services, primary health facilities, and health personnel are limited.

Conclusion

The growing numbers of elderly people represent a great challenge to health authorities in most countries. First, the demand for expensive dental care will increase for active older persons in addition to the frail and institutionalized elderly; second, public health authorities will have to face the growing burden of oral disease associated with the new chronic disease profile of aging societies. Failure to deal with these important demographic imperatives and rapid changes in disease patterns and interrelations will have behavioral, socioeconomic, and political consequences.

As shown in this review, general and associated oral health conditions have a direct influence on older people's QOL and lifestyle. The negative impact of poor oral health conditions on general health and QOL of older adults is an important public health issue; WHO recommends⁷ that countries develop national public health programs, based on integrated prevention and health promotion, and that measurable goals be formulated for improving the oral health of the elderly.

Acknowledgements

The authors wish to express their sincere appreciation to Dr. J.P. Lussier, former Dean of the Faculty of Dental Medicine, University of Montreal, Dr. Sophie Arpin,

Ph.D., and Dr. Charles Smith, senior scientist, Faculty of Medicine, University of Montreal, for their revision of the manuscript.

References

1. United Nations. *World population ageing 1950–2050*. New York: United Nations; 2002.
2. World Health Organization. *Active ageing: a policy framework*. Geneva: World Health Organization; 2002.
3. United Nations Population Division. *World population prospects: the 2002 revision*. New York: United Nations; 2003.
4. Heyden G. Health profile of the ageing population: the Swedish experience. *Int Dent J* 1998;48:167-72.
5. Sarment DP, Antonucci TC. Oral health-related quality of life and older adults. In: Inglehart M, Bagramian R, eds. *Oral health-related quality of life*. Chicago: Quintessence Books; 2002; 99-109.
6. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol* 2005;33:81-92.
7. Petersen PE. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century—the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol* 2003;31(Suppl. 1):3-23.
8. Belmin J, Chassagne Ph, Gonthier R, Jeandel C, Pfitzenmeyer P. *Gérontologie. Collection pour le praticien*. Masson (Paris); 2003.
9. Avlund K, Holm-Pedersen P, Schroll M. Functional ability and oral health among older people: a longitudinal study from age 75 to 80. *J Am Geriatr Soc* 2001;49:954-62.
10. Ettinger RL, Beck JD. Medical and psychosocial risk factors in the dental treatment of the elderly. *Int Dent J* 1983;33:292-300.
11. Shay K, Berkey D, Beck J, et al. The First International Conference on Rural Ageing; a global challenge. Proceedings of the Oral Health Component. Charleston, West Virginia, 2000. *Int Dent J* 2001;51:177-264.
12. Kandelman D, Brodeur JM, Simard P, Lepage Y. Dental needs of the elderly: a comparison between some European and North American surveys. *Community Dent Health* 1986;3:19-39.

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

13. Petersen PE, Nörtov B. General and dental health in relation to life-style and social network activity among 67-year-old Danes. *Scand J Prim Health Care* 1989;7:225-30.
14. Shah N, Sundaram KR. Impact of socio-demographic variables, oral hygiene practices and oral habits on periodontal health status of Indian elderly: a community-based study. *Indian J Dent Res* 2003;14:289-97.
15. Chalmers JM. Oral health promotion for our ageing Australian population. *Aust Dent J* 2003;48:2-9.
16. Österberg T, Mellström D, Sundh V. Dental health and functional ageing. A study of 70-year-people. *Community Dent Oral Epidemiol* 1990;18:313-8.
17. Norlén P, Östberg H, Björn AL. Relationship between general health, social factors and oral health in women at the age of retirement. *Community Dent Oral Epidemiol* 1991;19:296-301.
18. Katona CLE, Robertson MM. *Psychiatry at a glance*. Oxford: Blackwell Science; 1995.
19. Lewis S, Jagger RG, Treasure E. The oral health of psychiatric in-patients in South Wales. *Spec Care Dent* 2001;21:182-6.
20. Hede B, Petersen PE. Self-assessment of dental health among Danish noninstitutionalized psychiatric patients. *Spec Care Dent* 1992;12:33-6.
21. Genco RJ, Ho AW, Grossi SG, Dunford RG, Tedesco LA. Relationship of stress, distress and inadequate coping behaviors to periodontal disease. *J Periodontol* 1999;70:711-23.
22. Axtelius B, Söderfeldt B, Nilsson A, Edwardsson S, Attström R. Therapy-resistant periodontitis. Psychosocial characteristics. *J Clin Periodontol* 1998;25:482-91.
23. Persson GR, Persson RE, MacEntee CI, Wyatt CC, Hollender LG, Kiyak HA. Periodontitis and perceived risk for periodontitis in elders with evidence of depression. *J Clin Periodontol* 2003;30:691-6.
24. Shimazaki Y, Soh I, Koga T, Miyazaki H, Takehara T. Risk factors for tooth loss in the institutionalised elderly: a six-year cohort study. *Community Dent Health* 2003;20:123-7.
25. Henry R, Smith B. Treating patients with Alzheimer's and other late-life dementias. A guide for dental professionals. *Oral Health* 2005;10:26.
26. Adam H, Preston AJ. The oral health of individuals with dementia in nursing homes. *Gerodontology* 2006;23:99-105.
27. Chalmers JM, Carter KD, Spencer AJ. Oral diseases and conditions in community-living older adults with and without dementia. *Spec Care Dentist* 2003;23:7-17.
28. Nakayama Y, Washio M, Mori M. Oral health conditions in patients with Parkinson's disease. *J Epidemiol* 2004;14:143-50.
29. Johnston BT, Li Q, Castell JA, Castell DO. Swallowing and esophageal function in Parkinson's disease. *Am J Gastroenterol* 1995;90:1741-6.
30. Schembri A, Fiske J. The implications of visual impairment in an elderly population in recognizing oral disease and maintaining oral health. *Spec Care Dent* 2001;21:222-6.
31. Taylor CM, King JM, Sheiham A. A comparison of the dental needs of physically handicapped and non-handicapped elderly people living at home in Grimsby, England. *Gerodontology* 1986;2:80-2.
32. Schein OD, Hochberg MC, Muñoz B, Tielsch JM, Bandeen-Roche K, Provost T, Anhalt GJ, West S. Dry eye and dry mouth in the elderly: a population-based assessment. *Arch Intern Med* 1999;159:1359-63.
33. Närhi TO. Prevalence of subjective feelings of dry mouth in the elderly. *J Dent Res* 1994;73:20-5.
34. Locker D. Subjective reports of oral dryness in an older adult population. *Community Dent Oral Epidemiol* 1993;21:165-8.
35. Ship JA, Pillemer SR, Baum BJ. Xerostomia and the geriatric patient. *J Am Geriatr Soc* 2002;50:535-43.
36. Fox PC. Management of dry mouth. *Dent Clin North Am* 1997;41:863-75.
37. Bergdahl M, Bergdahl J. Low unstimulated salivary flow and subjective oral dryness: association with medication, anxiety, depression, and stress. *J Dent Res* 2000;79:1652-8.
38. Sreebny LM, Schwartz SS. A reference guide to drugs and dry mouth, 2nd ed. *Gerodontology* 1997;14:33-47.
39. Dawes C. Physiological factors affecting salivary flow rate, oral sugar clearance, and the sensation of dry mouth in man. *J Dent Res* 1987;66:648-53.
40. Atkinson JC, Wu AJ. Salivary gland dysfunction: causes, symptoms, treatment. *J Am Dent Assoc* 1994;125:409-16.
41. Slade GD, Strauss RP, Atchison KA, Kressin NR, Locker D, Reisine ST. Conference summary: assessing oral health outcomes—measuring health status and quality of life. *Community Dent Health* 1998;15:3-7.
42. Locker D. Dental status, xerostomia and the oral health-related quality of life of an elderly institutionalized population. *Spec Care Dent* 2003;23:86-93.
43. McMillan AS, Leung KC, Leung WK, Wong MC, Lau CS, Mok TM. Impact of Sjögren's syndrome on oral health-related quality of life in southern Chinese. *J Oral Rehabil* 2004;31:653-9.
44. Gerdin EW, Einarson S, Jonsson M, Aronsson K, Johansson I. Impact of dry mouth conditions on oral health-related quality of life in older people. *Gerodontology* 2005;22:219-26.
45. Matear DW, Locker D, Stephens M, Lawrence HP. Associations between xerostomia and health status indicators in the elderly. *J R Soc Health* 2006;126:79-85.
46. Knapp A. Nutrition and oral health in the elderly. *Dent Clin North Am* 1989;33:109-25.
47. Walls AW, Steele JG, Sheiham A, Marcenes W, Moynihan PJ. Oral health and nutrition in older people. *J Public Health Dent* 2000;60:304-7.
48. Soini H, Routasalo P, Lauri S, Ainamo A. Oral and nutritional status in frail elderly. *Spec Care Dentist* 2003;23:209-15.
49. Pla GW. Oral health and nutrition. *Prim Care* 1994;21:121-33.
50. Moynihan P, Petersen PE. Diet, nutrition and the prevention of dental diseases. *Public Health Nutr* 2004;7:201-26.
51. Dormenval V, Budtz-Jørgensen E, Mojon P, Bruyère A, Rapin CH. Nutrition, general health status and oral health status in hospitalised elders. *Gerodontology* 1995;12:73-80.
52. Schoenberg NE, Gilbert GH. Dietary implications of oral health decrements among African-American and white older adults. *Ethn Health* 1998;3:59-70.
53. Leake JL, Hawkins R, Locker D. Social and functional impact of reduced posterior dental units in older adults. *J Oral Rehabil* 1994;21:1-10.
54. Carlos JP, Wolfe MD. Methodological and nutritional issues in assessing the oral health of aged subjects. *Am J Clin Nutr* 1989;50(5 Suppl):1210-8.
55. Sheiham A, Steele JG, Marcenes W, Finch S, Walls AW. The impact of oral health on stated ability to eat certain foods; findings

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

- from the National Diet and Nutrition Survey of Older People in Great Britain. *Gerodontology* 1999;16:11-20.
56. Laurin D, Brodeur JM, Leduc N, Bourdages J, Lachapelle D, Vallée R. Nutritional deficiencies and gastrointestinal disorders in the edentulous elderly: a literature review. *J Can Dent Assoc* 1992;58:738-40.
 57. Sahyoun NR, Lin CL, Krall E. Nutritional status of the older adult is associated with dentition status. *J Am Diet Assoc* 2003;103:61-6.
 58. Petersen PE, Kjølner M, Christensen LB, Krustup U. Changing dentate status of adults, use of dental health services, and achievement of national dental health goals in Denmark by the year 2000. *J Public Health Dent* 2004;64:127-35.
 59. Sullivan DH, Martin W, Flaxman N, Hagen JE. Oral health problems and involuntary weight loss in a population of frail elderly. *J Am Geriatr Soc* 1993;41:725-31.
 60. Blaum CS, Fries BE, Fiatarone MA. Factors associated with low body mass index and weight loss in nursing home residents. *Int J Med Sci* 1995;50:162-8.
 61. Ritchie CS, Joshipura K, Silliman RA, Miller B, Douglas CW. Oral health problems and significant weight loss among community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* 2000;55:M366-71.
 62. Weyant RJ, Newman AB, Kritchevsky SB, Bretz WA, Corby PM, Ren D, Weissfeld L, Rubin SM, Harris T. Periodontal disease and weight loss in older adults. *J Am Geriatr Soc* 2004;52:547-53.
 63. Mohammad AR, Brunsvold M, Bauer R. The strength of association between systemic postmenopausal osteoporosis and periodontal disease. *Int J Prosthodont* 1996;9:479-83.
 64. Wactawski-Wende J, Grossi SG, Trevisan M, Genco RJ, Tezal M, Dunford RG, Ho AW, Hausmann E, Hreshchysyn MM. The role of osteopenia in oral bone loss and periodontal disease. *J Periodontol* 1996;67(10 Suppl):1076-84.
 65. Persson RE, Hollender LG, Powell LV, MacEntee MI, Wyatt CC, Kiyak HA, Persson GR. Assessment of periodontal conditions and systemic disease in older subjects. I. *J Clin Periodontol* 2002;29:796-802.
 66. Taguchi A, Tanimoto K, Suei Y, Otani K, Wada T. Oral signs as indicators of possible osteoporosis in elderly women. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;80:612-6.
 67. Birkenfeld L, Yemini M, Kase NG, Birkenfeld A. Menopause-related oral alveolar bone resorption: a review of relatively unexplored consequences of estrogen deficiency. *Menopause* 1999;6:129-33.
 68. Helme RD, Gibson SJ. The epidemiology of pain in elderly people. *Clin Geriatr Med* 2001;17:417-31.
 69. Chung JW, Kim JH, Kim HD, Kho HS, Kim YK, Chung SG. Chronic orofacial pain among Korean elders: prevalence and impact using the graded chronic pain scale. *Pain* 2004;112:164-70.
 70. World Health Organization. *The World Health Report 2007. A safer future: global public health security in the 21st century*. World Health Organization: Geneva; 2007.
 71. Limeback H. The relationship between oral health and systemic infections among elderly residents of chronic care facilities: a review. *Gerodontology* 1988;7:131-7.
 72. Russell SL, Boylan RJ, Kaslick RS, Scannapieco FA, Katz RV. Respiratory pathogen colonization of the dental plaque of institutionalized elders. *Spec Care Dentist* 1999;19:128-34.
 73. Scannapieco FA, Mylotte JM. Relationships between periodontal disease and bacterial pneumonia. *J Periodontol* 1996;67(10 Suppl):1114-22.
 74. Scannapieco FA. Role of oral bacteria in respiratory infection. *J Periodontol* 1999;70:793-802.
 75. Hayes C, Sparrow D, Cohen M, Vokonas PS, Garcia RI. The association between alveolar bone loss and pulmonary function: the VA Dental Longitudinal Study. *Ann Periodontol* 1998;3:257-61.
 76. Mojon P, Budtz-Jørgensen E, Michel JP, Limeback H. Oral health and history of respiratory tract infection in frail institutionalised elders. *Gerodontology* 1997;14:9-16.
 77. Sumi Y, Miura H, Sunakawa M, Michiwaki Y, Sakagami N. Colonization of denture plaque by respiratory pathogens in dependent elderly. *Gerodontology* 2002;19:25-9.
 78. Loesche WJ, Lopatin DE. Interactions between periodontal disease, medical diseases and immunity in the older individual. *Periodontol* 2000 1998;16:80-105.
 79. Schreiner A. Anaerobic pulmonary infections. *Scand J Infect Dis Suppl* 1979;19:77-9.
 80. Donowitz GR, Mandell GL. Acute pneumonia. In: Mandell GL, Douglas RG, Bennett JE, eds. *Principles and practice of infectious diseases*, 3rd ed. New York: Churchill Livingstone; 1990; 540-55.
 81. Finegold SM. Aspiration pneumonia. *Rev Infect Dis* 1991;13(Suppl 9):S737-42.
 82. Langmore SE, Terpenning MS, Schork A, Chen Y, Murray JT, Lopatin D, Loesche WJ. Predictors of aspiration pneumonia: how important is dysphagia? *Dysphagia* 1998;13:69-81.
 83. Quagliarello V, Ginter S, Han L, Van Ness P, Allore H, Tinetti M. Modifiable risk factors for nursing home-acquired pneumonia. *Clin Infect Dis* 2005;40:1-6.
 84. Mattila KJ, Valle MS, Nieminen MS, Valtonen VV, Hietaniemi KL. Dental infections and coronary atherosclerosis. *Atherosclerosis* 1993;103:205-11.
 85. Beck J, Garcia R, Heiss G, Vokonas PS, Offenbacher S. Periodontal disease and cardiovascular disease. *J Periodontol* 1996;67(10 Suppl):1123-37.
 86. Beck JD, Offenbacher S. The association between periodontal diseases and cardiovascular diseases: a state-of-the-science review. *Ann Periodontol* 2001;6:9-15.
 87. DeStefano F, Anda RF, Kahn HS, Williamson DF, Russell CM. Dental disease and risk of coronary heart disease and mortality. *BMJ* 1993;306:688-91.
 88. Joshipura KJ, Rimm EB, Douglass CW, Trichopoulos D, Ascherio A, Willett WC. Poor oral health and coronary heart disease. *J Dent Res* 1996;75:1631-6.
 89. Joshipura KJ, Hung HC, Rimm EB, Willett WC, Ascherio A. Periodontal disease, tooth loss, and incidence of ischemic stroke. *Stroke* 2003;34:47-52.
 90. Meurman JH, Qvarnström M, Janket SJ, Nuutinen P. Oral health and health behavior in patients referred for open-heart surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003;95:300-7.
 91. Beck JD, Elter JR, Heiss G, Couper D, Mauriello SM, Offenbacher S. Relationship of periodontal disease to carotid artery intima-media wall thickness: the Atherosclerosis Risk in Communities (ARIC) study. *Arterioscler Thromb Vasc Biol* 2001;21:1816-22.
 92. Loesche WJ, Schork A, Terpenning MS, Chen YM, Kerr C, Dominguez BL. The relationship between dental disease and cerebral vascular accident in elderly United States veterans. *Ann Periodontol* 1998;3:161-74.

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

93. Mattila KJ, Nieminen MS, Valtonen VV, Rasi VP, Kesäniemi YA, Syrjälä SL, Jungell PS, Isoluoma M, Hietaniemi K, Jokinen MJ. Association between dental health and acute myocardial infarction. *BMJ* 1989;298:779-81.
94. Grau AJ, Buggle F, Ziegler C, Schwarz W, Meuser J, Tasman AJ, Bühler A, Benesch C, Becher H, Hacke W. Association between acute cerebrovascular ischemia and chronic and recurrent infection. *Stroke* 1997;28:1724-9.
95. Kweider M, Lowe GD, Murray GD, Kinane DF, McGowan DA. Dental disease, fibrinogen and white cell count; links with myocardial infarction? *Scott Med J* 1993;38:73-4.
96. Genco RJ, Wu TJ, Grossi SG, Falkner K, Zambon JJ, Trevisan M. Periodontal micro flora related to the risk for myocardial infarction: a case control study. *J Dent Res* 1999;78:2811.
97. Wu T, Trevisan M, Genco RJ, Dorn JP, Falkner KL, Sempos CT. Periodontal disease and risk of cerebrovascular disease: the first national health and nutrition examination survey and its follow-up study. *Arch Intern Med* 2000;160:2749-55.
98. Mattila KJ, Asikainen S, Wolf J, Jousimies-Somer H, Valtonen V, Nieminen M. Age, dental infections, and coronary heart disease. *J Dent Res* 2000;79:756-60.
99. Hujoel PP, Drangsholt MT, Spiekerman C, DeRouen TA. Periodontal disease and coronary heart disease risk. *JAMA* 2000;284:1406-10.
100. Howell TH, Ridker PM, Ajani UA, Hennekens CH, Christen WG. Periodontal disease and risk of subsequent cardiovascular disease in U.S. male physicians. *J Am Coll Cardiol* 2001;37:445-50.
101. Weksler ME. Age-associated changes in the immune response. *J Am Geriatr Soc* 1982;30:718-23.
102. Paunio K, Impivaara O, Tiekso J, Mäki J. Missing teeth and ischaemic heart disease in men aged 45-64 years. *Eur Heart J* 1993;14(Suppl K):54-56.
103. Matsumura K, Ansai T, Awano S, Takehara T, Abe I, Iida M, Takata Y. Association of dental status with blood pressure and heart rate in 80-year-old Japanese subjects. *Jpn Heart J* 2003;44:943-51.
104. Lagervall M, Jansson L, Bergström J. Systemic disorders in patients with periodontal disease. *J Clin Periodontol* 2003;30:293-9.
105. Syrjälä J, Peltola J, Valtonen V, Iivanainen M, Kaste M, Huttunen JK. Dental infections in association with cerebral infarction in young and middle-aged men. *J Intern Med* 1989;225:179-84.
106. Ettinger RL. Changing dietary patterns with changing dentition: how do people cope? *Spec Care Dentist* 1998;18:33-9.
107. Papapanou PN. Periodontal diseases: epidemiology. *Ann Periodontol* 1996;1:1-36.
108. Loe H. Periodontal disease. The sixth complication of diabetes mellitus. *Diabetes Care* 1993;16:329-334.
109. Grossi SG, Genco RJ. Periodontal disease and diabetes mellitus: a two-way relationship. *Ann Periodontol* 1998;3:51-61.
110. Thorstensson H, Hugoson A. Periodontal disease experience in adult long-duration insulin-dependent diabetics. *J Clin Periodontol* 1993;20:352-8.
111. Gottsegen R. Diabetes and periodontal disease. *J Periodontol* 1991;62:161-3.
112. Thorstensson H, Huylenssterna J, Hugoson A. Medical status and complications in relation to periodontal disease experience in insulin-dependent diabetics. *J Clin Periodontol* 1996;23:194-202.
113. Scheinin A, Pienihäkkinen K, Tiekso J, Holmberg S, Fukuda M, Suzuki A. Multifactorial modeling for root caries prediction: 3-year follow-up results. *Community Dent Oral Epidemiol* 1994;22:126-9.
114. Takano N, Ando Y, Yoshihara A, Miyazaki H. Factors associated with root caries incidence in an elderly population. *Community Dent Health* 2003;20:217-22.
115. Lawrence HP, Hunt RJ, Beck JD. Three-year root caries incidence and risk modeling in older adults in North Carolina. *J Public Health Dent* 1995;55:69-78.
116. Greenlee RT, Murray T, Bolden S, Wingo PA. Cancer statistics, 2000. *CA Cancer J Clin* 2000;50:7-33.
117. Silverman S Jr, Gorsky M. Epidemiologic and demographic update in oral cancer: California and national data—1973 to 1985. *J Am Dent Assoc* 1990;120:495-9.
118. Silverman S Jr. Precancerous lesions and oral cancer in the elderly. *Clin Geriatr Med* 1992;8:529-41.
119. Lewin F, Norell SE, Johansson H, Gustavsson P, Wennerberg J, Björklund A, Rutqvist LE. Smoking tobacco, oral snuff, and alcohol in the etiology of squamous cell carcinoma of the head and neck: a population-based case-referent study in Sweden. *Cancer* 1998;82:1367-75.
120. Pajukoski H, Meurman JH, Snellman-Gröhn S, Sulkava R. Oral health in hospitalized and nonhospitalized community-dwelling elderly patients. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999;88:437-43.
121. Thomas G, Hashibe M, Jacob BJ, Ramadas K, Mathew B, Sankaranarayanan R, Zhang ZF. Risk factors for multiple oral premalignant lesions. *Int J Cancer* 2003;107:285-91.
122. Epstein JB, Lunn R, Le ND, Stevenson-Moore P, Gorsky M. Patients with oropharyngeal cancer: a comparison of adults living independently and patients living in long-term facilities. *Spec Care Dentist* 2005;25:124-30.
123. Kowalski LP, Franco EL, Torloni H, Fava AS, de Andrade Sobrinho J, Ramos G, Oliveira BV, Curado MP. Lateness of diagnosis of oral and oropharyngeal carcinoma: factors related to the tumour, the patient and health professionals. *Eur J Cancer B Oral Oncol* 1994;30B:167-73.
124. Reichart PA. Oral mucosal lesions in a representative cross-sectional study of aging Germans. *Community Dent Oral Epidemiol* 2000;28:390-8.
125. Sepehr A, Kamangar F, Fahimi S, Saidi F, Abnet CC, Dawsey SM. Poor oral health as a risk factor for esophageal squamous dysplasia in northeastern Iran. *Anticancer Res* 2005;25:543-6.
126. Sarment DP, Antonucci TC. Oral health-related quality of life and older adults. In: Inglehart M, Bagramian R, eds. *Oral health-related quality of life*. Chicago: Quintessence Books; 2002; 99-109.
127. McGrath C, Bedi R. A national study of the importance of oral health to life quality to inform scales of oral health related quality of life. *Qual Life Res* 2004;13:813-8.
128. Cassolato SF, Turnbull RS. Xerostomia: clinical aspects and treatment. *Gerodontology* 2003;20:64-77.
129. Kane RA, Kane RL. *Assessing the elderly: a practical guide to measurement*. Lexington, MA: D.C. Heath; 1981.
130. Bowling A. *Measuring health: a review of quality of life measurement scales*. Buckingham: Open University Press; 2004.
131. Mariño R, Calache H, Wright C, Schofield M, Minichiello V. Oral health promotion programme for older migrant adults. *Gerodontology* 2004;21:216-25.

ORAL AND GENERAL HEALTH IN OLDER PEOPLE

132. Hassel AJ, Koke U, Drechsel A, Kunz C, Rammelsberg P. Oral health-related quality of life in elderly. *Z Gerontol Geriatr* 2005;38:342-6.
133. Shtereva N. Aging and oral health related to quality of life in geriatric patients. *Rejuvenation Res* 2006;9:355-7.
134. Locker D, Matear D, Stephens M, Jokovic A. Oral health-related quality of life of a population of medically compromised elderly people. *Community Dent Health* 2002;19:90-7.
135. Locker D, Clarke M, Payne B. Self-perceived oral health status, psychological well-being, and life satisfaction in an older adult population. *J Dent Res* 2000;79:970-5.
136. Gift HC, Atchison KA, Drury TF. Perceptions of the natural dentition in the context of multiple variables. *J Dent Res* 1998;77:1529-38.
137. MacEntee MI, Hole R, Stolar E. The significance of the mouth in old age. *Soc Sci Med* 1997;45:1449-58.
138. Jones JA. Using oral quality of life measures in geriatric dentistry. *Community Dent Health* 1998;15:13-8.
139. Hebling E, Pereira AC. Oral health-related quality of life: a critical appraisal of assessment tools used in elderly people. *Gerodontology* 2007;24:151-61.
140. White BA. Use of oral health related quality of life measures in managed dental care organisations. *Community Dent Health* 1998;15:27-31.
141. Petersen PE, Kwan S. Evaluation of community-based oral health promotion and oral disease prevention—WHO recommendations for improved evidence in public health practice. *Community Dent Health* 2004;21:319-29.
142. Awad MA, Lund JP, Shapiro SH, Locker D, Klemetti E, Chehade A, Savard A, Feine JS. Oral health status and treatment satisfaction with mandibular implant overdentures and conventional dentures: a randomized clinical trial in a senior population. *Int J Prosthodont* 2003;16:390-6.
143. Heydecke G, Locker D, Awad MA, Lund JP, Feine JS. Oral and general health-related quality of life with conventional and implant dentures. *Community Dent Oral Epidemiol* 2003;31:161-8.
144. Att W, Stappert C. Implant therapy to improve quality of life. *Quintessence Int* 2003;34:573-81.
145. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. *Community Dent Oral Epidemiol* 2005;33:81-92.
146. Leake JL, Martinello BP. Oral health status of independent elderly persons in London, Ontario. *J Can Dent Assoc* 1972;38:31-4.
147. Martinello BP. Oral health assessment of residents of a Chatam, Ontario, home for the aged. *Dent J* 1976;42:405-8.
148. Kandelman D, Lepage Y. Demographic, social and cultural factors influencing the elderly to seek dental treatment. *Int Dent J* 1982;32:360-70.
149. Nordenram G, Bohlin E. Dental status in the elderly: a review of the Swedish literature. *Gerodontology* 1985;4:3-24.
150. Slade GD, Locker D, Leake JL, Price SA, Chao I. Differences in oral health status between institutionalized and non institutionalized older adults. *Community Dent Oral Epidemiol* 1990;18:272-6.
151. Petersen PE. Social inequalities in dental health. Towards a theoretical explanation. *Community Dent Oral Epidemiol* 1990;18:153-8.
152. Chen M. *Comparing oral health systems. A second international collaborative study*. Geneva: World Health Organization; 1997.
153. Petersen PE. Strengthening the prevention of oral cancer: the WHO perspective. *Community Dent Oral Epidemiol* 2005;33:397-9.
154. Kelly M, Walker A, Cooper I, eds. *Adult dental health survey: oral health in the United Kingdom 1998: a survey*. London: The Stationery Office; Office for National Statistics; Social Survey Division; 2000.
155. Brodeur J-M, Simard P, Kandelman D. *Projet étude sur la santé bucco-dentaire des personnes de 65 ans et plus: rapport final*. Grant from National Program for Research and Development. Quebec: Health & Welfare Canada; 1982.
156. Petersen PE. Dental visits and self-assessment of dental health status in the adult Danish population. *Community Dent Oral Epidemiol* 1983;11:162-8.
157. Ambjørnsen E. Remaining teeth, periodontal condition, oral hygiene and tooth cleaning habits in dentate old-age subjects. *J Clin Periodontol* 1986;13:583-9.
158. Ikebe K, Watkins CA, Ettinger RL, Sajima H, Nokubi T. Application of short-form oral health impact profile on elderly Japanese. *Gerodontology* 2004;21:167-76.
159. Petersen PE. Sociobehavioural risk factors in dental caries—international perspectives. *Community Dent Oral Epidemiol* 2005;33:274-9.
160. Krstrup U, Petersen PE. Dental caries prevalence among adults in Denmark—the impact of socio-demographic factors and use of oral health services. *Community Dent Health* 2007;24:225-32.
161. Krstrup U, Petersen PE. Periodontal conditions in 35–44 and 65–74 year old adults in Denmark. *Acta Odontol Scand* 2006;64:65-73.
162. Hujoel PP, Drangsholt M, Spiekerman C, DeRouen TA. Periodontitis—systemic disease associations in the presence of smoking—causal or coincidental? *Periodontol 2000* 2002;30:51-60.
163. Tuominen R, Reunanen A, Paunio M, Paunio I, Aromaa A. Oral health indicators poorly predict coronary heart disease deaths. *J Dent Res* 2003;82:713-8.
164. Taylor GW. Bidirectional interrelationships between diabetes and periodontal diseases. An epidemiological perspective. *Ann Periodontol* 2001;6:99-112.
165. Rothman KJ, Greenland S. Causation and causal inference. In: Detels R, ed. *Oxford textbook of public health*, 4th ed. Oxford: Oxford University Press; 2004; 641-53.
166. Petersen PE. Inequalities in oral health: the social context for oral health. In: Pine CM, Harris R, eds. *Community oral health*, 2nd ed. London: Quintessence; 2007; 31-58.
167. World Health Organization. *Ottawa Charter for Health Promotion*. Ottawa: World Health Organization; Health and Welfare Canada; Canadian Public Health Association; 1986.
168. World Health Organization. The Bangkok Charter for health promotion in a globalized world. 6th global conference on health promotion, Bangkok, Thailand, August 2005.