Contents

Foreword

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It is now over 10 years since the first edition of *Oral Healthcare and the Frail Elder* was published. This edition is a significant expansion from the previous one. Interesting new chapters have been added and the emphasis has shifted from the clinical to a more philosophical and global approach.

The population of the US and Canada is aging. However, as people age, they are influenced by a variety of behaviors, such as poor diets, high sugar intakes, sedentary lifestyles which result in suboptimal exercise, and misuse of tobacco, alcohol, and drugs which lead to many chronic noncommunicable diseases (NCD). With age, the culmination of these diseases is frailty both systemic and oral. Another complicating factor, according to the WHO, which can lead to frailty is the persistent and pervasive advertising and influence of the sugar, alcohol, and tobacco industries as increased consumption of these products can cause a variety of NCDs. These systemic and oral diseases have long latency periods before the development of acute exacerbations, for which there is no cure.

Oral healthcare is unfortunately not uniformly accessible in most countries. The fact is that the most vulnerable members of our society are the most likely to face the greatest barriers for receiving inadequate oral healthcare. The impact of not caring for these oral noncommunicable diseases (dental caries, periodontitis, mucositis, tooth loss, and some cancers) in frail older adults is magnified and has an impact on the quality of their life, general health, and morbidity and mortality. Caries is the most prevalent of these diseases and in general, preventive programs in the frail population have been a failure. The relationship between periodontal disease and other NCDs such as diabetes, cardiovascular disease, dementia, and mortality has been intensely studied. This relationship may be that periodontal disease and these other diseases share age-related inflammatory responses.

Unfortunately, total loss of teeth has been accepted in many cultures as the normal price of aging. In many frail older adults, the entry into long-term care has been associated with a breakdown in the dentition. The incidence of oral precancers and cancers is significant in frail populations. The social, emotional, and biological consequences of oral NCDs in frail older adults are discussed in detail in this book.

The purpose of the book is to provide the reader with the functional knowledge needed to understand the frail older population and to help clinicians develop and provide evidence-based care.

Preface: The Challenge of Aging and Frailty and Why a Second Edition?

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I will apply the regimens of treatment according to my ability and judgment for the benefit of my patients and protect them from harm and injustice... [and] Into whatever house I enter; I will do so for the benefit of the sick...

Source: Adapted from the Hippocratic Oath, translation by Nicholas Dunkas, MD (Retsas, 2019)

Why a Second Edition?

It is 10 years since the first edition of this book appeared and much has happened. Above all, there is mounting evidence that the dental and other healthcare professions are beginning to approach the challenges of oral health and related care in old age differently and more constructively than we did a decade ago. This change is occurring slowly but progressively, and it has prompted an

extensive reconsideration of the information in the first edition. Consequently, in constructing this new edition, we are responding to the following.

- There has been a substantial increase over the last decade in the population of frail and disabled elders who need continuous, safe, effective transdisciplinary care at home for as long as possible, and in residential facilities where available as their frailty and dependency on others increase (Table 1).
- Healthcare professions are now more aware than ever of these demographic and healthcare challenges as they search for their appropriate roles within the complicated environment of transdisciplinary care.
- It is clear that mouthcare is integral to general health in all age groups and possibly even more with increasing frailty.
- Knowledge of disease and disability has increased over the last decade, and many of the beliefs and recommendations in the original edition warrant revision to explain current challenges and barriers to oral health, and to better prepare dental and other professions for the needs and demands of frail elders.
- Oral diseases sit prominently within the context of noncommunicable disease that the World Health Organization (2020) identifies as a major global challenge for human development, a leading cause of morbidity, and disproportionately burdensome within low-income communities. Yet the curative interventions favored by the dental professions tend mainly to the biomedical demands of affluent communities (Watt et al., 2019).
- There is a need in dental geriatrics for a global focus on the principles of population and public health and of equity in healthcare by acknowledging that oral healthcare succeeds only by recognizing that oral disease and disability are, like cardiovascular disease, diabetes, cancer, obesity, and other noncommunicable diseases, influenced strongly by the pervasive social and commercial determinants of health and unrelenting social inequalities (Benzian et al., 2021).

This new edition attends closely to these upstream determinants of health as the foundation underlying a broad range of strategies for effectively managing the oral healthcare of frail elders. We focus particularly on people who are frail and unable to access the usual dental services accessible to older people. This acknowledges the broad challenges of oral healthcare in the context of noncommunicable disease, and health equity as a compounding challenge to frailty. Our evidence is drawn from, and relevant to, the international community of clinicians, public health providers, educators, and researchers in the dental and other health professions. We provide information that is highly relevant to public health and residential care administrators, policy makers, nurses, nutritionists, speech therapists, and physicians attending elders who are home-bound or in residential care.

Table 1 Five-year probability of survival with low or high frailty and co-morbidity.

Condition		Low frailty, no co-morbidity			High frailty, high co-morbidity		
Age in years		75	80	85	75	80	85
Survival %	Women	93	88	78	65	58	44
	Men	89	82	70	55	49	38

Source: Adapted from Schoenborn et al. (2022).

Overall, this book provides an evidence-based foundation of clinical knowledge from a global perspective for managing the oral health of frail elders.

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1

Demography of Aging and Frailty, and the Epidemiology of Oral Conditions

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This chapter covers the population aspects of aging and oral health. First, we consider the demography of aging and frailty, followed by a look at the aging process itself. Multimorbidity and frailty, including the notion of oral frailty, are described. We also provide an epidemiological overview of the common oral conditions, including tooth loss, dental caries, periodontitis, dry mouth, oral mucosal lesions, and temporomandibular disorders.

Demography of Aging and Frailty

The Aging Population

Worldwide, increased life expectancy and falling birth rates, which are largely a consequence of improved public health actions, have meant that the number and proportion of older people in many countries have increased. This rise has been rapid and is expected to continue. By 2050, 2.1 billion people, or 1 in 6, will be aged over 60 years, which is double the current older population. Within that group, the oldest-old (≥85 years) will increase the most, tripling current levels by 2050. While the age-related demographic changes up to now have predominantly occurred in high-income countries, it is the low- and middle-income countries where growth is expected in the future; by 2050, two-thirds of the global older population will reside in low- and middle-income countries.

Conceptualizing Aging

Aging is an inevitable feature of the human experience. Efforts to understand it have resulted in a plethora of explanatory biological and social theories (Table 1.1). No single theory fully explains aging, which underlines its complex and multifactorial nature. Moreover, the biological events involved in aging take place within social norms and societal contexts, which themselves show considerable variation.

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Table 1.1 Theories of aging.

Theory	Brief description
Biological theories[a]	
Replicative senescence	Somatic cells are capable of a finite number of divisions.
Accumulated mutation	Accumulation of somatic damage from "wear and tear" and compromised repair of DNA.
Antagonistic pleiotropy	Genes favoring survival in youth at the cost of harm in old age.
Disposable soma	Biological priority to perpetuate the species is followed by ineffective repair and maintenance of somatic cells when reproduction is complete.
Social theories[b]	
Activity theory	Participation in enjoyable social activities promotes health and satisfaction in old age.
Disengagement theory	Gradual withdrawal from previously held roles benefits both the individual and society.
Continuity theory	Substitution of new roles for past activities and responsibilities as adaptation to age-associated changes occur. This challenges both activity theory and disengagement theory.

[a] Adapted from Lipsky and King (2015).
[b] Adapted from Hasworth and Cannon (2015).

While we all age at the same rate chronologically, there is considerable variation in rates of biological aging. Elliott et al. (2021) recently characterized and described differences in the pace of aging among participants followed to age 45 years in the Dunedin Multidisciplinary Health and Development Study, a prospective study which (to date) has followed a complete birth cohort to midlife. Using a composite measure assembled from 19 different biomarkers representing the cardiovascular, metabolic, renal, immune function, oral, and pulmonary domains, the pace of aging in the cohort was found to range from 0.4 to 2.4 biological years per chronological year. Participants who were aging faster already had poorer cognitive and sensorimotor function, along with anatomical evidence of higher brain age and central nervous system degeneration assessed using magnetic resonance scans. That these differences were already apparent by age 45 means that noncommunicable disease (NCD) trajectories are already well-established by midlife. They arise from individual differences in genetic endowment, cellular biology, life-experiences and exposures. Such aging has usually involved decades of subclinical decline—in, variously, the cardiovascular, metabolic, renal, immunological, neurological, and pulmonary organ systems—prior to clinical manifestation, diagnosis, and management later in life. Thus, as people pass through late middle age and into old age, their ongoing decline manifests as a steadily accumulating number of chronic conditions requiring medical or surgical intervention (Thomson, 2023).

Multimorbidity

Multimorbidity is defined as the co-existence of two or more conditions in the same individual (Jose et al., 2009). Conditions that commonly cluster include diabetes, hypertension, osteoarthritis, dementia, dyslipidaemia, depression, heart failure, and cancer (Ofori-Asenso et al., 2018; Skou et al., 2022). Estimates of multimorbidity vary according to the data source and how it is defined (Gontijo Guerra et al., 2019; Johnston et al., 2019). Recent metaanalyses provide a global prevalence

ranging from 37.2% in the community (Chowdhury et al., 2023) to 42.4% in a combination of community and healthcare settings (Ho et al., 2022). Disparities in the prevalence of multimorbidity by gender, socioeconomic status, and ethnicity are evident, with higher prevalence among women, those living in deprivation, and in indigenous and ethnic minority groups (Stanley et al., 2018; Quiñones et al., 2021; Alshakhs et al., 2022; Ho et al., 2022; Chowdhury et al., 2023).

The prevalence of multimorbidity also increases with age, a consequence of the slow progression of chronic conditions and longer life-expectancy, and (in turn) the high prevalence of chronic conditions among older people. Most people aged over 60—and virtually all of the oldest old—live with two or more chronic conditions (Ofori-Asenso et al., 2018; Ho et al., 2022; Chowdhury et al., 2023). The number of conditions also rises with age (Chowdhury et al., 2023). The combination of population aging and the rising prevalence of chronic conditions means that multimorbidity is a substantial global public health concern (Pearson-Stuttard, et al., 2019).

Multimorbidity has considerable consequences for older people, including functional decline and greater disability, poor quality of life, a higher risk of hospitalization and longer hospital stays, polypharmacy, and premature death (Skou et al., 2022). There are also implications for their families, communities, health systems, and society. Individuals with multimorbidity rely on family members and others to support the usual activities of daily living (ADL), which can range from shopping and housework to full personal care. For the health system, the substantial expenditure associated with high health service-use, including health and social care, is a considerable burden (Skou et al., 2022; Tran et al., 2022). Managing the care of someone with multimorbidity is complex, requiring a well-coordinated, comprehensive, and person-centered approach (Whitty et al., 2020; Skou et al., 2022). Treating each condition singly typically results in inadequate and inefficient care, and a high probability of iatrogenic damage through polypharmacy. Apparently, the cost of caring for someone with multimorbidity is greater than that for each single condition combined (Tran et al., 2022).

As the proportion of older people in the population continues to rise, so too will the demand on health and social services, along with associated financial costs (Prince et al., 2015). Given that most health and social services are underresourced, especially in low- and middle-income countries, and inadequately prepared, it is challenging to appropriately addressing the future needs of people with multimorbidity.

Chronic conditions are patterned by exposure over time to a range of risks, such as environmental, social, and workplace influences, and the individual behaviors resulting from those exposures, including diet, physical activity, use of tobacco and alcohol, and poor access to health services (Marmot, 2005; Peters et al., 2019).

Frailty

Frailty is closely related to aging. It arises from a decline in functioning in multiple physiological systems, with a resultant higher vulnerability to stressors. Frailty is characterized by a loss of biological reserves, a failure of physiological mechanisms, and vulnerability to a range of adversities, including multimorbidity, cognitive decline, late-life dependency, and premature death. Conceptually and physically, it overlaps with disability and the accumulated burden of NCDs. There are two widely cited conceptual approaches to measuring frailty (Walston, 2021): the model of *physical frailty*, characterized as a phenotype arising from the loss of biological reserve with subsequent weakness, fatigue, weight loss, and slowing down; and the model of *deficit accumulation*, understood as the accumulation of deficits from illnesses and disability, along with cognitive and functional decline, that drives frailty.

The global prevalence of frailty remains unclear, owing to such classification differences and a lack of nationally representative data. A recent systematic review of available population-level studies from 62 countries indicated a prevalence for frailty of between 1 in 8 and 1 in 4 older adults, with little change in prevalence since 2012 (O'Caoimh et al., 2021). It also highlighted *pre-frailty* as a recognized prodromal state before the onset of clinically identifiable frailty, with sarcopenia in old age as a key precursor. There was an overall estimate of 12% for physical frailty and 24% for the deficit accumulation model. For pre-frailty, the respective estimates were 46% and 49%. These estimates underline the importance of frailty as a gerontological state.

Oral Frailty

The concept of "oral frailty" has emerged in recent years with the term "oral hypofunction" applied to the oral manifestations of aging-associated sarcopenia and dry mouth (Minakuchi et al., 2018). Oral hypofunction is determined by identifying seven clinical signs; five represent functional aspects of oral musculature and two represent bacterial counts and moisture on the dorsum of the tongue. While it remains unclear whether the concept implies a syndrome, there is the possibility that treating oral hypofunction could help slow the rate of onset of general frailty. It is noteworthy that, in the absence of convincing evidence of its efficacy from interventional studies, the treatment of oral hypofunction has already been included in the Japanese dental payment schedule. At this early stage, questions remain about the validity of this approach, and whether its philosophical basis fits with contemporary biopsychosocial concepts of positive aging.

Importance of the Life-Course

Appreciating the life-course journey is crucial to understanding aging and oral health. The dental literature on older people has almost exclusively focused on the personal behaviors and exposures leading to the burden of chronic oral conditions, without considering the course of life leading to a particular point in time. Such a narrow focus has not been helpful, enabling misinterpretation of much of the available evidence. A wider perspective is needed and, when considered, has revealed that the circumstances and consequences of the past typically have a lasting effect on developments throughout life (Gilleard and Higgs, 2016; Heckhausen and Wrosch, 2016; MacEntee et al., 2019; Thomson, 2023).

People with what we would consider to be "good oral health" in old age are those who have adapted successfully to the burden of their oral disease, accumulated over the years. They are able to chew, taste, and enjoy their food, and to smile and speak comfortably and without social embarrassment (MacEntee et al., 1997; Locker, 1988). They may have retained most of their natural teeth, maybe they are complete denture-wearers, or they may have a combination of these. Successful oral aging cannot be defined solely by the outdated concept of a complete dentition, that is, whether someone is with or without teeth or their replacements.

Thus, the concept of adequate oral functioning is considerably broader than the biomedical notions which have largely predominated to date (McGrath et al., 2022). Given the value placed by older people on social engagement, independence, physical health, and positive attitudes (Reich et al., 2020), having a mouth and dentition that enables those is important. Accordingly, a biopsychosocial and functional concept is more appropriate, given the wide variation in biological status observed in older populations. The biopsychosocial model emphasizes the interconnections among biological, psychological and socioenvironmental factors in determining health states, and it is consistent with the definition of healthy aging as "developing and maintaining the functional ability that enables well-being in older age" (World Health Organization, 2015).

Understanding how people's health develops is critical to understanding and accepting the biopsychosocial model of oral health in old age.

It can be helpful to consider the three types of capital pertaining to the resources used to achieve and maintain health (Frytak et al., 2002). *Financial* capital is someone's income and wealth, upon which consumption of health-promoting goods is highly dependent. *Human* capital is the investments in education and training that enable people to avoid risky exposures or behaviors. S*ocial* capital comprises their personal relationships and interactions. Using experiences with dental caries as a simple example, financial capital enables the purchase of fluorided toothpaste and a healthier diet, together with being able to afford ongoing maintenance of the dentition; human capital enables the long-term practice of a health-promoting behavior, such as twice-daily toothbrushing; and social capital would be apparent through the social norm of having clean white teeth, and a full complement of anterior teeth (Thomson, 2023).

Being operative day after day over many decades of life, the three forms of capital favor less dental caries and more tooth retention. Comparing people with more capital against those with less capital at any age during the life-course will show marked differences in rates of oral disease and in numbers of missing teeth. Comparisons at older ages will show greater differences, consistent with the cumulative nature of both exposure and outcome. An appreciation of such processes is crucial for understanding and interpreting epidemiological data on the oral status of older people.

Epidemiology of Oral Conditions in Older People

Tooth loss, dental caries, periodontitis, dry mouth, oral mucosal lesions, and musculoskeletal disorders are the most impactful oral conditions observed in older populations (Kassebaum et al., 2017). They are all chronic and noncommunicable. The more common chronic oral conditions, such as dental caries and periodontitis, are cumulative in nature, which means that their extent and severity generally increase with age. Tooth loss can be a consequence of either condition, which makes the interpretation of dental epidemiological information on dental caries and periodontitis challenging. The complication arises from the fact that, as teeth are gradually lost over time because of either of those conditions, the remaining teeth are essentially the healthy survivors. The same issue arises at the personal level, whereby people living into their seventh decade and beyond are relatively healthy survivors, and differ in important and meaningful ways from those who did not survive. Consider also the cumulative nature of dental caries, periodontitis and consequent tooth loss, where the earliest exposures to the various causes will have commenced very distally indeed and then accrued day by day, week by week, month by month as the life-course unfolded.

All these considerations make the interpretation of oral epidemiological data on older people a complicated exercise, fraught with difficulties. In the sections which follow, we summarize what is currently known about the occurrence of tooth loss, dental caries, periodontitis, dry mouth, oral mucosal lesions, and musculoskeletal disorders in older populations.

Edentulism and Incremental Tooth Loss

Edentulism is the state of having had all natural teeth removed. By contrast, incremental tooth loss is the gradual loss of teeth, whether due to dental caries, severe periodontitis, orofacial trauma or other reasons, as people move through life. People who are edentate have had all their remaining natural teeth removed, usually after many years of incremental tooth loss, which is as much a

social as a clinical decision (Sanders et al., 2004; Sussex et al., 2010; Gibson et al., 2017; Goulart et al., 2019). It requires the patient and dentist to have colluded in the decision to remove the remaining teeth. Edentulism is usually considered by dentists to be an undesirable, "biographically disruptive" endpoint representing the failure of both self-care and the dental care system (Rousseau et al., 2014), but the transition to edentulism can also mark the end of decades of misery and eating problems with impaired natural teeth (Thomson, 2014).

The combination of disease-related and sociocultural influences makes complete tooth loss a complex phenomenon. It is relatively easy to measure, usually by self-reports, which obviates the need for the systematic and detailed clinical examination (Gilbert et al., 1999; Høvik et al., 2022). Accordingly, edentulism has been the focus of much investigation, with a search on PubMed revealing almost 2000 articles published between 1983 and 2023, with two peaks in published reports in 2015–2018 and 2021–2022.

Edentulism is strongly and positively associated with age (Slade et al., 2014; Ren et al., 2017). For example, in Switzerland in 2012, fewer than 1 in 100 of those younger than 45 years were edentate, in contrast to about 1 in 10 of 75–84 year olds (Schneider et al., 2017). In China at that time, fewer than 1 in 50 aged 45–54 years and about one-third of those aged 75 or more were edentate (Ren et al., 2017). In Brazil, while 6% of the overall adult population were edentate in 2010, it was 77% among older people (Cardoso et al., 2016).

There are also marked socioeconomic and education-level differences in complete tooth loss, observable in both cross-national comparisons (Tyrovolas et al., 2016; Borg-Bartolo et al., 2022) and within-country investigations (Suominen-Taipale et al., 1999; Olofsson et al., 2018). There are also large differences in tooth loss by income among countries (Tyrovolas et al., 2016), whereby the prevalence of edentulism in countries with Gross National Income <$15,000 is about one-third higher than in countries where the Gross National Income is >$45,000. Moreover, tooth loss is increasing in low- and middle-income countries while continuing to decrease in high-income countries. It is also more prevalent in rural than urban populations (Sussex, 2008), and where dental services are readily accessible (Mojon, 2003; Winkelmann et al., 2022).

The prevalence of complete tooth loss has decreased in recent decades by about 1% every year in high-income countries for various reasons, but that decline has leveled off recently, contrary to earlier predictions (Suominen-Taipale et al., 1999; Mojon et al., 2004; Thomson, 2012; Slade et al., 2014; Cardoso et al., 2016). For example, among Swiss 65–74 year olds, the annual decline in edentulism between 1992 and 2002 was around 1.1%, but it was only 0.8% for the following decade (Schneider et al., 2017). Without much doubt, very few young adults in wealthy countries today lose all their natural teeth; however, complete tooth loss from the maxilla is likely to remain highly prevalent for the foreseeable future, and especially in older populations (Cardoso et al., 2016).

There are notable social influences on the occurrence of incremental tooth loss, defined as the unplanned, episodic loss of some but not all natural teeth. Very few people reach old age without losing one or more teeth. For example, there is a wide diversity of residual dentitions and associated use of dentures among older New Zealanders, but rarely are there completely intact dentitions in this age group (Hyland et al., 2019, 2022). A number of cohort studies of older adults demonstrated that incremental tooth loss continues in people aged 65 or older (Drake et al., 1995; Locker et al., 1996; Slade et al., 1997; Gilbert et al., 1999; Warren et al., 2002; De Marchi et al., 2012).

In high-income European countries, there has been a decline in the proportion of adults with 1–5 teeth missing (Suominen-Taipale et al., 1999; Unell et al., 2015; Schneider et al., 2017). While diseases play an important role in the incremental loss of teeth, on many occasions is to prevent future pain, to lower the cost associated with dental treatment, or to minimize the anxiety caused by dental treatment (Bouma et al., 1987). Cultural factors, including societal norms and beliefs

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Box 2.1 Noncommunicable diseases

The global burden and threat of noncommunicable diseases constitutes a major public health challenge that undermines social and economic development throughout the world.

These major noncommunicable diseases share four behavioral risk factors: tobacco use, unhealthy diet, physical inactivity and harmful use of alcohol… exposure to risk factors begins in early life.

Noncommunicable diseases and their risk factors also have strategic links to health systems and universal health coverage, environmental, occupational and social determinants of health… and ageing.

Source: Adapted from World Health Organization (2013)

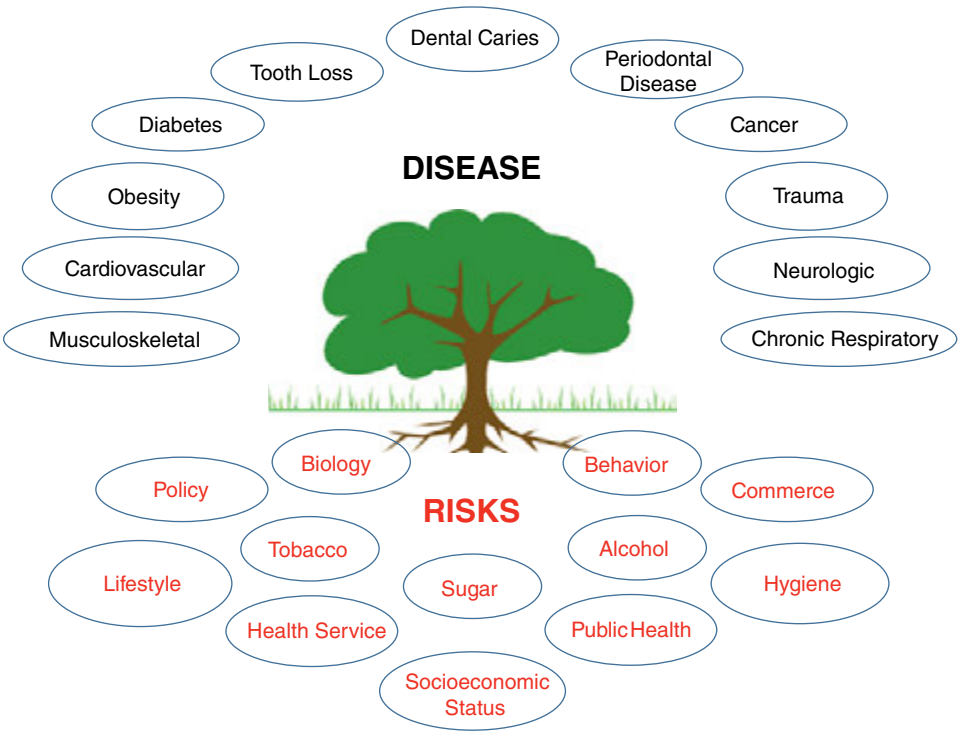

Figure 2.1 Noncommunicable diseases and associated risks.

in some jurisdictions, and there is widespread interest in creating similar health-related controls on the sale of sugar and alcohol (Task Force, 2019; World Bank, 2020; Milsom et al., 2021; Lee and Freudenberg, 2022). In 2015, the United Nations aimed to reduce premature deaths from NCDs by one-third before 2030 as part of its Sustainable Development Goals. Yet nearly a decade later, the major diseases—cardiovascular disease, diabetes, cancer, chronic respiratory diseases, and obesity—are collectively the leading cause of morbidity and death globally, and disproportionately burdensome to aging, frail, low-income, and other vulnerable communities (Allen et al., 2021).

Box 2.2 Strategic action plan for noncommunicable diseases

- Raise national and international priority of prevention and control
- Strengthen national capacity and multisectoral action
- Reduce modifiable risk factors and social determinants
- Implement sustainable people-centered primary healthcare and universal health coverage
- Enhance workforce capacity and related research
- Monitor trends and evaluate progress

World Health Organization (2013, 2022)

Frailty

The prevalence of frailty depends on how it is diagnosed. It is, according to Hakeem et al. (2019):

> a state characterised by reduced physiological reserve and higher vulnerability to stressors which leads to adverse health outcomes including dependency, functional impairment, cognitive decline and death...

and diagnosed when a person has three or more physical signs involving weight loss, exhaustion, weakness, and slowness or inactivity (Ribeiro et al., 2020). In the older (>60 years) populations, about 11% in high-income and 17% in low-income countries are frail (Rohrmann, 2020). Like NCD, it is influenced by an array of biological, psychological, and social risks, including old age, multimorbidity, polypharmacy, psychosocial health, access to care, and socioeconomic status. Frail people typically have multiple NCDs, some more disturbing than others. Extensive tooth loss, for example, predisposes to poor nutrition, sacropenia, and frailty (Moynihan and Teo, 2024). Frailty in or around the mouth has been defined specifically as an "age-related functional decline of orofacial structures" and associated with one or more oral activities (Box 2.3).

We know little about the incidence or predictable transitions of frailty over time, nor about cause–effect relationships between frailty and NCDs. They share many risks, which suggests common explanatory pathways influenced, for example, by nutrition, inflammation, and psychosocial stress (Fong, 2019; Hakeem et al., 2019; Rohrmann, 2020), although it is not certain that treating NCDs will reduce frailty. In short, the associations between NCDs, including oral conditions, and frailty in older populations are challenging.

Box 2.3 Decline in activities with oral frailty

1) Mastication—difficulty eating hard or tough foods, and inability to chew all types of foods
2) Swallowing—decreased ability to swallow solid foods, decreased ability to swallow liquids, and overall poor swallowing function
3) Oral motor skill—impaired tongue movement and speech/phonation disorders
4) Salivation—hyposalivation or xerostomia

Source: Adapted from Parisius et al. (2024). www.sciencedirect.com/science/article/pii/S0167494323002595, last accessed 12 July 2024

Noncommunicable Diseases of the Mouth

The burden of oral NCDs—dental caries, periodontitis, tooth loss, and cancer— increased globally between 1990 and 2015, and proportionately more in vulnerable communities (Kassebaum et al., 2017; Peres et al., 2019; Chan et al., 2021; Wen et al., 2022). Management of the burden has been complicated by an inadequate workforce, restricted access to appropriate care, and expensive but essentially ineffective treatments (MacEntee et al., 1999, 2012; Donnelly et al., 2016; Chen et al., 2020; Winkelmann et al., 2022; World Health Organization, 2022; Marchini and Ettinger, 2023). Drug-induced dry mouth (Nguyen et al., 2014; Thomson et al., 2021) and poor oral hygiene (Hoben et al., 2017; Ruiz-Roca et al., 2021) are among the more obvious examples of inappropriate care for frail elders. Further, the burden is elevated by the pervasive marketing of transnational sugar, alcohol, and tobacco industries (Jamieson et al., 2020; World Health Organization, 2022).

With these and other concerns, the World Health Organization (WHO) proposed a plan of action for oral health based on principles of inclusion, equity, and social justice to resist the sugar industry's upstream influence, integrate oral healthcare with other healthcare services, and lower the financial barriers to cost-effective treatments (Box 2.4). This plan also promotes the idea of including oral healthcare as part of universal health coverage to provide healthcare without financial hardship or environmental damage (Wang et al., 2020; Martin et al., 2022; Winkelmann et al., 2023).

We will continue from here with a focus on the four major NCDs of the mouth—dental caries, periodontal disease, tooth loss, and oral cancer—that burden frail people as they age.

Dental Caries

The risk of dental caries, like many other NCDs, is linked through a widespread web of social, personal, and oral influences (Figure 2.2). It is among the most prevalent NCDs and, like others, has ill effects that accumulate throughout life and impose the heaviest burden on unhealthy and low-income communities (Broadbent et al., 2008; Wen et al., 2022). Typically, it causes toothache, although in older teeth it can develop and progress without discomfort or pain until the sharp edges of a cavitated or broken tooth injures the adjacent tongue and cheek. Eventually, the accumulated effect of caries leads to tooth loss that is sufficient over a lifetime to increase the

Box 2.4 A strategic action plan for oral health

1) **Inclusion and community engagement**.
2) **Place equity and social justice at the core** of all policies and fully aligned with the goals of primary healthcare and Universal Health Coverage.
3) **Tackle sugars as a major common risk factor** to strengthen upstream population-wide measures and resist industry interference with oral health and NCD strategies.
4) **Embrace major system reforms** with cost-effective interventions, integrative delivery and financing models, and appropriate educating of oral healthcare professionals.
5) **Develop monitoring and evaluation systems** integrated with existing healthcare systems to enhance data on oral health needs and care.
6) **Close financing gaps** as part of the overall financing agenda for noncommunicable disease, by increasing public investments in low- and middle-income countries, and reallocating funds towards cost-effective "best-buy" interventions.

Source: Benzian et al. (2021)/with permission of Elsevier

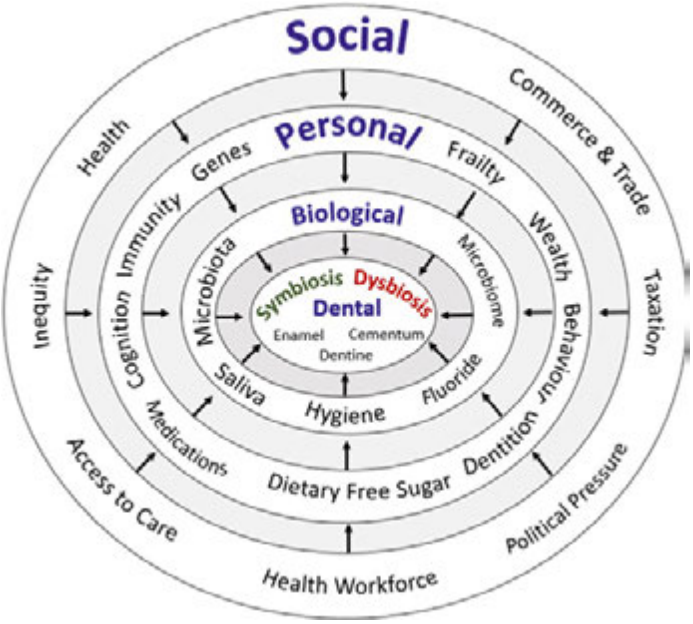

Figure 2.2 Web of dental caries as a noncommunicable disease.

risk of nutritional deficiency, low self-esteem, and possibly frailty (MacEntee et al., 1997; Thomson, 2023).

About half the older population have untreated carious lesions, following a lifelong prevalence in the permanent dentition that peaks around age 25 years, drops to late middle age, and slowly increases to peak again around age 70 years (Figure 2.3). It is a trajectory of disease with little improvement over recent decades in older populations (Bernabé et al., 2016; Hong et al., 2020; Chan et al., 2021), and influenced strongly by socioeconomic variation both between and within regions (Wen et al., 2022). Normally, the dynamic demineralization and remineralization of tooth structure is a stable process until frailty or some other disorder disturbs the ability of saliva to buffer acids produced from free sugars by microorganisms in the mouth. The term "cavities,"

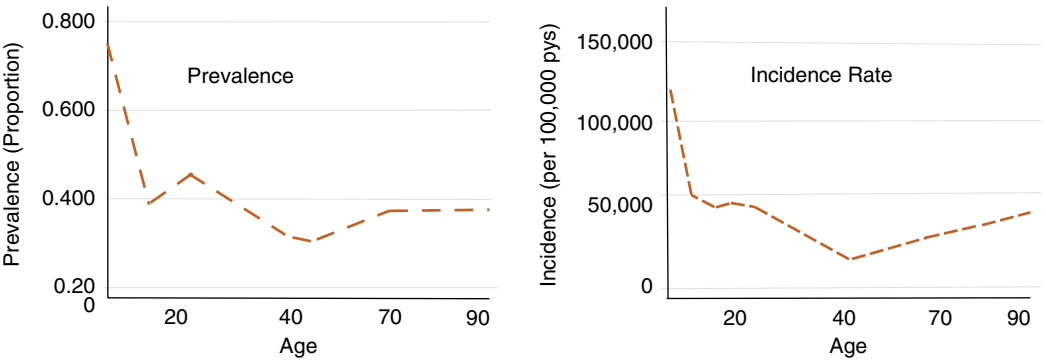

Figure 2.3 Global burden of untreated dental caries in permanent teeth. Prevalence (proportion) and incidence (per 100,000 person-years). *Source:* Adapted from Kassebaum et al. (2015).

following the biochemical demineralization of dental surfaces, confuses distinction between the process of *active* demineralization that is dental caries and the cavities in teeth caused by the disease (Machiulskiene et al., 2020).

Saliva is key to maintaining oral homeostasis and preserving, repairing, and sustaining tooth structure, and medication-associated dry mouth and poor clearance of food from the mouth greatly increase the risk of dental caries (Pitts et al., 2021; Thomson et al., 2021). Furthermore, the environmental response of each mouth differs. In a two-year longitudinal study of very frail people in residential care, most (82%) of them at baseline had clinical evidence of carious lesions (MacEntee et al., 1990). On average during year 1 they lost a tooth and had another restored, so, at the end of the year, they had fewer carious lesions. Overall, new or recurrent lesions appeared in one-third of the 40 participants during year 1 but in over three-quarters (78%) of the 18 remaining participants in year 2. The total net effect produced an average incidence per person of 0.88 demineralized lesions in year 1 and 3.39 lesions in year 2, which is a serious increase. However, only one participant in year 1 and two in year 2 had more than three lesions—one had seven new lesions in year 1 and 13 in year 2, whilst another had 19 in year 1 alone. Excluding the two highly susceptible participants reduced the average net incidence of carious surfaces per person only a little in year 1 but very substantially to 1.81 (SE 0.48) lesions in year 2. Apart from the more refined evidence of carious incidence, this small longitudinal investigation demonstrates the skewing effects of a few very susceptible "outliers" on our knowledge of dental caries in old age.

Preventive strategies to modify harmful behaviors have been strikingly ineffective, while initial efforts to control the sale of sugar, much like controls on tobacco and alcohol, are extremely challenging against the pervasive sociopolitical and commercial interests of the transnational sugar industry (Watt et al., 2019; Wen et al., 2022). Either way, downstream efforts focused on reducing the risk of caries to individual patients are generally ineffective, and upstream efforts to mitigate the risk, as with other NCDs, are extremely difficult to implement and sustain. Meanwhile, dental caries continues as one of the most prevalent NCDs threatening the health and quality of life of people who are old and frail.

Periodontal Disease

The epidemiology of periodontal disease in older populations illustrates further the complexity of NCDs. Firstly, loss of periodontal attachment (LOA)—the primary measure of periodontal disease—is a result of past rather than current disease activity. It can increase or remain static over long periods. Hence, the prevalence of LOA is higher in older than younger populations, although older people are not necessarily at greater risk, nor does the incidence of the disease increase with age (Figure 2.4). The peak incidence of severe LOA occurs in middle age, but, the consequence persists throughout life, and with it an elevated risk of tooth-loss (Eke et al., 2018; Kassebaum et al., 2014a,b; Haworth et al., 2018).

There have been many studies of relationships between periodontal disease and other NCDs, notably type 2 diabetes, cardiovascular disease, dementia, and frailty (Clark et al., 2021).

Diabetes is a metabolic NCD characterized by hyperglycemia due to an absolute or relative deficiency of insulin. Type 2 or noninsulin-dependent diabetes occurs typically in older age groups whereby insulin fails to promote the metabolic ingestion of glucose (Preshaw and Bissett, 2019; Sanz et al., 2020). There is some evidence of a bidirectional causal relationship between type 2 diabetes and periodontitis but it is still doubtful (Polak and Shapira, 2018; Simpson et al., 2022). In one direction, for which the evidence is reasonably strong, type 2 diabetes activates local immune and inflammatory responses within the periodontium that retard healing of periodontal tissues

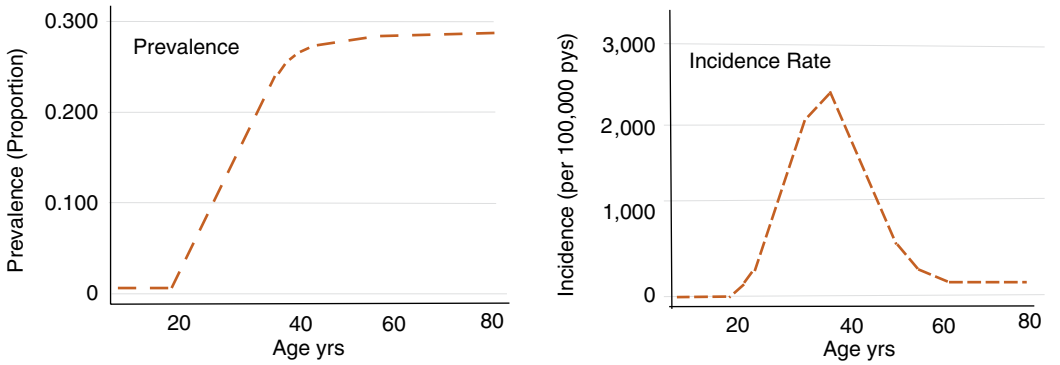

Figure 2.4 Global burden of >6 mm loss of periodontal attachment. Prevalence (proportion) and incidence (per 100,000 person-years). *Source:* Adapted from Kassebaum et al. (2014a).

(Figure 2.5). The evidence supporting the influence of periodontitis on systemic inflammation and diabetic complications is plausible but much weaker (Pihlstrom et al., 2018a,b). It is plausible also that similar links exist between periodontitis and other NCDs, mediated by systemic age-related inflammatory responses (Franceschi and Campisi, 2014). But, for now, there is considerable heterogeneity and potential bias in the evidence for these causal relationships (Cao et al., 2019; Hakeem et al., 2019), and also there is little consensus on optimal indicators of successful

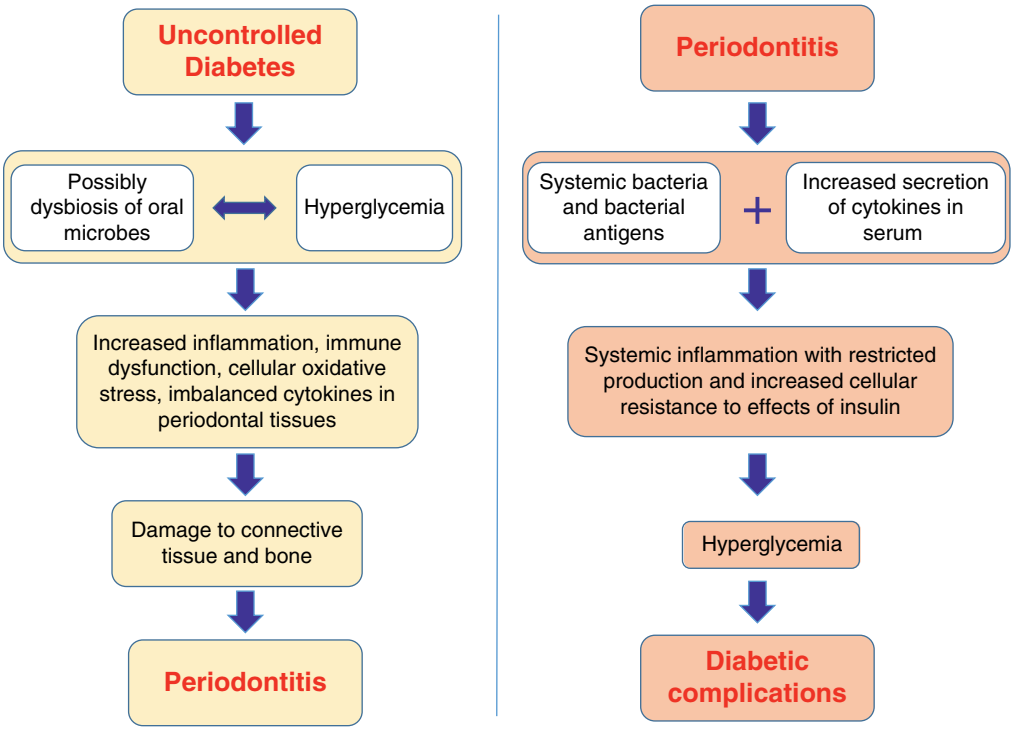

Figure 2.5 Possible links between periodontitis and type 2 diabetes. *Source:* Adapted from Polak and Shapira (2018).

treatments, especially for older people who are frail. Moreover, it will be methodologically challenging and expensive to collect the evidence necessary to confirm the bidirectional relationship between different NCDs because they have so much risk in common (Sheiham and Watt, 2000; Thomson and Barak, 2021).

In conclusion, older populations have a high prevalence of LOA, but the incidence of continuing loss with age is low. Undoubtedly, periodontal disease is associated with a number of NCDs and with frailty, but the evidence is weak for a therapeutic cause-and-effect association other than with diabetes mellitus. It is very unlikely, for example, that periodontal treatment will prevent or cure dementia, but it might stabilize frailty by preventing tooth loss to improve mastication and the appeal of a healthy diet.

Tooth Loss

The prevalence of severe loss typically begins to rise in late middle age, peaking around age 60 years, but most people have some natural teeth for a lifetime (Figure 2.6). The prevalence of severe (<9 teeth) or complete tooth loss has declined over the last half-century. For example, in 2002 nearly half (45%) of the Swiss population over 85 years had complete dentures, whereas it was 15% a decade later (Schneider et al., 2017). This optimistic trend has not occurred everywhere, especially where incomes are low and people are old and frail (Stock et al., 2016; Elani et al., 2017), and a substantial proportion (>2%) of the global population has no natural teeth (Kassebaum et al., 2014b). There are communities, even with high incomes, where cultural traditions encourage young women to get complete "dowry dentures" before marriage (Sussex et al., 2010; Russell et al., 2013; Goulart et al., 2019).

Edentulism, like reduced vision and hearing loss, is tolerated in many communities as an evitable consequence of aging, while others find it very distressing (MacEntee et al., 1997, 2019; Gibson et al., 2017; Al-Sahan et al., 2020; Yan et al., 2022). Accommodation to partial loss can be very effective, with a "shortened dental arch" providing functional contacts between anterior and premolar teeth (Gerritsen et al., 2013; Schierz et al., 2021). Apparently, people change their diet or just manage uncomfortable dentures (Millwood and Heath, 2000; Moynihan and Varghese, 2022; Al-Sultani et al., 2023).

Again like other NCDs, the biological consequence of losing teeth is continuous and unpredictable. Residual alveolar ridges continue to resorb, probably throughout the life-course (Tallgren, 1972). The consequences are ridge contours, mucosal coverings, and an unstable neuromusculature that

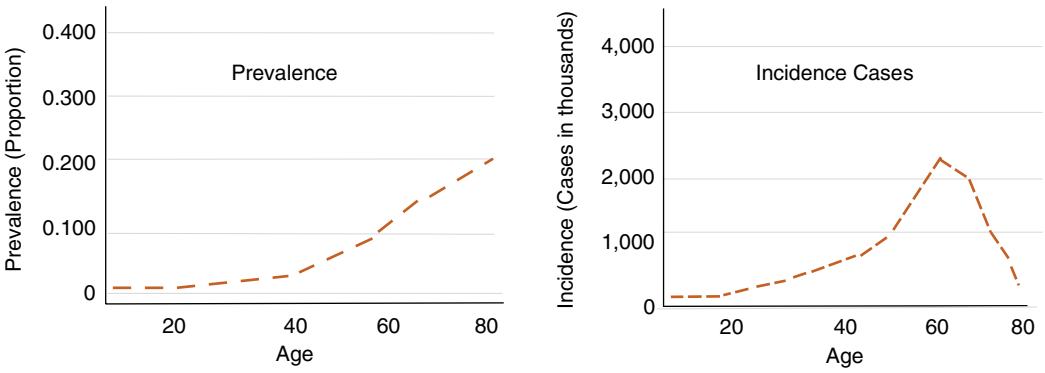

Figure 2.6 Global burden of severe tooth loss. Prevalence (proportion) and incidence (per 100,000 person-years) of severe loss (<9) of teeth. *Source:* Adapted from Kassebaum et al. (2014b).

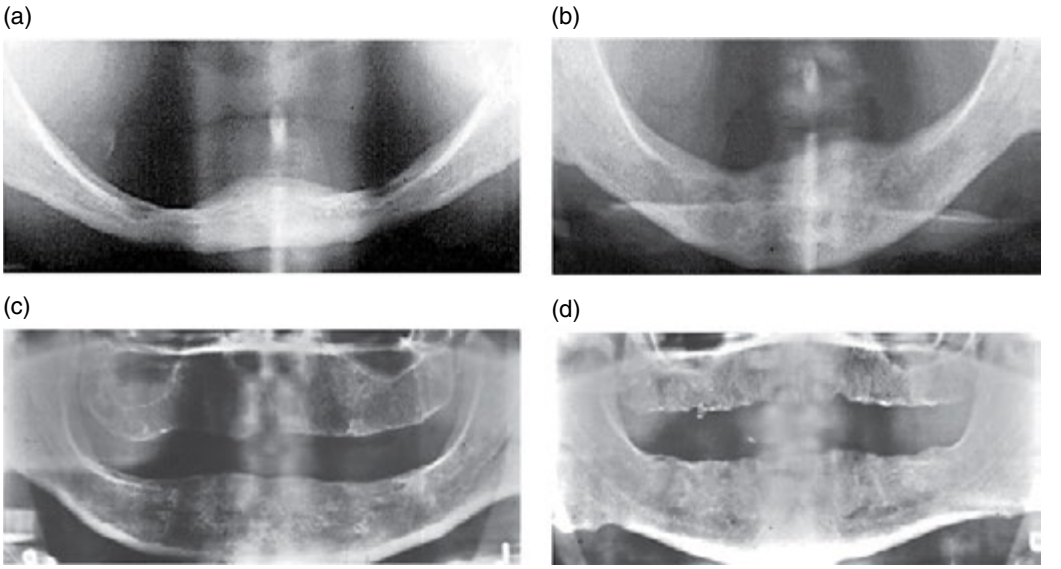

Figure 2.7 Residual ridge resorption. Radiographs (a) and (b): elderly sisters who lived together and wore complete dentures since age 21 years. Radiographs (c) and (d): unrelated elders who have been edentate for at least 20 years. *Source:* Courtesy of Professor CP Owen.

challenges even the most tolerant denture wearers, and quite possibly hastens the onset and progress of frailty (Figure 2.7).

Oral Cancers

The incidence of oral and lip cancers to age 75 years is about 2% of the 2 million or so new cancers and cancer-related deaths worldwide. It increases with age, peaks in late middle age, and possibly declines in old age (Ferlay et al., 2020), but the apparent decline might be due to poor vigilance of old mouths rather than reduced biological risk (Radkiewicz et al., 2022). Oral cancer is the eighteenth most common cancer globally, with more than one-third of the world's oral cancer cases diagnosed in India (Sung et al., 2021); South Asian migrants have a higher incidence of oral cancer than the general population in high-income countries (Moles et al., 2008; Auluck et al., 2010). Survival rate for oral cancer improves with early diagnosis, and about half of those afflicted survive for at least five years. Oral squamous cell carcinomas (SCC) are usually preceded by premalignant lesions, so routine screening for oral cancer is strongly recommended (Odell et al., 2021). Nearly all (~90%) oral cancers are SCCs, so the need for vigilance remains when examining the mouth, even if the person is frail, and especially if they use tobacco, alcohol, or betel quid (Warnakulasuriya, 2009).

Oral potentially malignant disorders include leukoplakia (white patch), erythroplakia (red patch), and oral lichen planus (Warnakulasuriya and Kerr, 2021). Leukoplakia and erythroplakia are clinical terms and not diagnoses. It is difficult to distinguish premalignant from benign lesions because both may have similar clinical appearances. In general, a biopsy is required for a definitive diagnosis when a white, red or ulcerated lesion of unknown origin has been present for three or more weeks.