Dental caries and periodontal diseases in the ageing population: call to action to protect and enhance oral health and wellbeing as essential component of healthy ageing. Consensus report of group 4 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases.

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Clinical Relevance

Scientific rationale. Longer life expectancy, increase in tooth retention into older age and increasing expectation of oral health related quality of life among elders are providing greater challenges for the prevention and treatment of caries and periodontitis later in life.

Practical implications. Chronological age is no longer an adequate criterion for making strategic decisions for the delivery of oral care to elders. Preservation of a functional dentition and oral health related quality of life into older age brings health benefits beyond the mouth as it allows good nutrition and may delay onset of dependency and frailty. This can be achieved by applying age-adequate effective preventive and treatment strategies for both caries and periodontal diseases. Reduction of morbidity due to caries and periodontitis later in life requires effective care as elders become increasingly dependent and treatment barriers arise.

Conclusions Prevention of caries and periodontitis as a means of retaining teeth for life is an important strategy for older adults. Health care systems need to adapt to the challenges by systemwide changes to enable tooth retention and management of deteriorating oral health especially in increasingly dependent elders.

Running title: *Caries, periodontal diseases and healthy ageing*

Abstract

Background: Over the last two decades, progress in prevention and treatment of caries and periodontal diseases has been translated to better oral health and improved tooth retention in the adult population. The ageing population and the increasing expectations of good oral health related quality of life in older age pose formidable challenges to clinical care and health care systems. **Aims** of this workshop were to critically review scientific evidence and develop specific recommendations to: (i) prevent tooth loss and retain oral function through prevention and treatment of caries and periodontal diseases later in life, and (ii) increase awareness of the health benefits of oral health as an essential component of healthy ageing.

Methods: Discussions were initiated by three systematic reviews covering aspects of epidemiology of caries and periodontal diseases in elders, the impact of senescence on caries and periodontal diseases and the effectiveness of interventions. Recommendations were developed based on evidence from the systematic reviews and expert opinion. **Results**: Key messages included: (i) the aging population, trends in risk factors and improved tooth retention point towards an expected increase in the total burden of disease posed by caries and periodontal diseases in the older population; (ii) specific surveillance is required to monitor changes in oral health in the older population; (iii) senescence impacts oral health including periodontitis and possibly caries susceptibility; (iv) evidence indicates that caries and periodontal diseases can be prevented and treated also in older adults; (v) oral health and functional tooth retention later in life provides benefits both in terms of oral and general quality of life and in terms of preventing physical decline and dependency by fostering a healthy diet; (vi) oral health care professionals and individuals should not base decisions impacting tooth retention on chronological age but on level of dependency, life-expectancy, frailty, comfort and quality of life; and (vii) health policy should remove barriers to oral health care for vulnerable elders. **Conclusions**: Consensus was reached on specific actionable priorities for public health officials, oral health care professionals, educators and workforce planners, caregivers and relatives as well as for the public and ageing patients. Some priorities have major implications for policy makers as health systems need to adapt to the challenge by systemwide changes to enable (promote) tooth retention later in life and management of deteriorating oral health in increasingly dependent elders.

Introduction

Across age groups caries and periodontal diseases are amongst the most prevalent diseases in mankind and, if untreated, lead to tooth loss, edentulism, loss of masticatory function, poor nutrition status, as well as loss of self-esteem, social difficulties and diminished quality of life. Cavitated caries lesions, severe periodontitis and the consequent tooth loss translate into a burden of disease estimated at 12,900,000 disability-adjusted life years in 2015 (G.B.D.-DALYs-Hale-Collaborators, 2016) or about 2% of the total burden of human disease. Treatment of caries, periodontitis and replacement of teeth lost for these two diseases represented the overwhelming majority of the estimated yearly economic impact of dental disease in 2010: US$298 billion direct costs, US$144 billion in indirect costs leading to a total economic impact of US$442 billion. Direct costs for dental treatment represent an estimated 4.6% of total medical expenditure worldwide (Listl et al., 2015).

Populations across the world are aging as a consequence of changes in fertility and mortality rates and the process is particularly advanced in industrialized nations (United Nations 2015). The current challenge is to add health to life years as the progressive improvement in the health of older people that translates in longevity may have stalled (World Health Organization 2015). In the 2013 update of the burden of disease study, the increase in life expectancy at birth of the world population was not associated with an increase in healthy life years, but rather with an increase in years lived with disability (G.B.D.-DALYs-Hale-Collaborators, 2016). These trends have implications for health system sustainability and social development (United Nations 2015). In this context health policy-makers are progressively shifting from the concept of prolonging the life span in calendar years towards favouring quality years, meaning years of life in good health. This implies the compression (reduction) of morbidity at the end of life. This novel concept also involves oral health, requiring treatment concepts that assure oral health, masticatory function and oral health related quality of life until the end of life, or at least for as long as possible. In fact it is well recognized that good oral health is a key factor in healthy ageing and is associated with general health, morbidity and mortality in elders (Holm-Pedersen et al., 2008). Current trends observed from the burden of disease study indicated a 45% decrease in the prevalence of severe tooth loss between 1990 and 2010 and are encouraging as efforts to effectively prevent

and treat caries and periodontal diseases are translating into improved tooth retention (Kassebaum et al., 2014). These data, however, indicate that the peak incidence of severe tooth loss is at 65 years of age and this has not changed over the past two decades. The challenge is to extend these health gains into older age and to the vulnerable segments of the aging population.

The aims of this consensus conference were: i) to summarize the best available evidence on the burden of caries and periodontal diseases in the older population; ii) to elucidate the impact that the biology of senescence, risk factors and comorbidities may have on these highly prevalent diseases; iii) to assess age-adequate effective strategies to preserve oral health and interventions to retain a functioning dentition into older age which are tailored to the degree of dependency of the individual rather than chronological age; iv) to identify standardized and relevant outcome measures in documenting and monitoring oral health in the elder population for scientific- and public health research; and v) to present a call to action to protect and enhance oral health and wellbeing as an essential component of healthy ageing for discussion with the multiple stakeholders.

Epidemiology of ageing, dental caries and periodontal diseases

Key measures for surveillance of periodontal diseases and caries in the aging population

The following measures used for surveillance of periodontal diseases and caries in other age groups can also be applied to the aging independent population:

- Tooth loss (missing teeth) is the result of untreated or unsuccessfully treated periodontal disease and/or caries and is responsible for masticatory dysfunction and impaired quality of life. As such it is relevant to assess the combined burden of both diseases in the later stages of severity. It is a robust measurement. However, tooth loss may also be due to other factors which sometimes are difficult to identify (Jepsen et al., 2017).
- Periodontal diseases are assessed by measuring and recording full-mouth attachment levels, probing pocket depths, and inflammation (bleeding on probing). To describe severity and extent, these parameters are reported as distributions. Partial mouth recording results in variable degrees of under- or overestimation (Baelum et al., 1993).
- Caries is assessed by recording the number of both coronal- and root caries lesions, their severity and location. The activity status of the carious lesions is also recorded, and past caries experience is recorded as the number of existing restorations (for missing teeth: see above).
- Oral health related quality of life is measured with specific instruments, such as OHIP or GOHAI (Slade, 2012). These can also be applied to an aging population without severe cognitive impairment. These instruments cover a range of dimensions, like functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, handicap. For reasons of practicality, in an aging population the short version of the available instruments may be more suitable.

The burden of caries and periodontal diseases over lifetime

There are various aspects that need to be captured (Jepsen et al., 2017):

The incidence, defined as newly detected cases of a disease, e.g. subjects with severe periodontitis or individuals with any carious lesions or caries experience. The result of incidence is prevalence, defined as the proportion of a population having a specific disease. For severe periodontitis, the peak incidence occurs between age 30 and 50 years (Kassebaum

et al., 2014), with the prevalence remaining basically the same afterwards. For caries, the peak incidence occurs before age 30 years (Kassebaum et al., 2015), and the prevalence similarly remains the same after that.

However, the damage due to both periodontitis and caries is largely irreversible and therefore cumulative over the lifetime (Lopez et al., 2017): neither the incidence nor the prevalence capture the resulting increase in extent (number of affected teeth, surfaces, sites) and severity (degree of disease experience on site, tooth or patient level) of this cumulative damage. Changes in extent and severity are determined by disease progression, that is the rate of new caries lesions or lesion progression or new periodontal attachment loss.

Given the described cumulative nature, disease experience - that is attachment level (lifetime attachment loss) or caries experience - increases with age. Although there is no clear indication that the disease progression rate changes with age, it is plausible that immune senescence leads to an increase in disease progression (Preshaw et al., 2017). However, while robust evidence for this is lacking, it is obvious that with age the exposure to risk factors for both diseases changes, which may increase the disease progression rate. In summary, disease experience is certainly increasing *with* age, but not necessarily *due to* age per se.

As the extent and severity of both diseases increase with age, the complexity of required treatment efforts also increases. Eventually, the increasing severity of both diseases will ultimately result in tooth loss (Hugoson et al., 2005, Slade et al., 2014).

The relationship between caries/periodontal diseases and age

The relationship between age and both caries and periodontal diseases is complex. Age may affect both diseases directly, possibly via immune and cellular senescence as well as impaired wound healing (Preshaw et al., 2017, Lopez et al., 2017), and indirectly via physical and cognitive impairment as well as reduced access to care. No matter whether the relationship is direct or indirect, the limited available epidemiological evidence suggests that older people are more vulnerable to caries and periodontal disease (G.B.D.-Risk-Factors-Collaborators et al., 2015).

Trends in the epidemiology of caries and periodontal disease in older age groups

There are:

(1) observable, past epidemiologic trends in both diseases, and

(2) expected, future upward trends in their risk factors

For the global population, data for elders is too sparse to describe any trends. In some industrialized countries and regarding the independent elderly population, more teeth are retained, a lower prevalence of severe periodontitis is observed and coronal (and possibly also root) caries experience is reduced (Jordan and Micheelis, 2016, Dye et al., 2015) compared with previous surveys (Dye et al., 2004, Micheelis and Schiffner, 2006), as described in detail in a systematic review (Lopez et al., 2017). In the dependent elderly, such trends cannot be described, while there is evidence that dependent elders and older people with cognitive impairment have poorer oral health than independent elders and people without cognitive impariment (Jordan and Micheelis, 2016).

In considering future trends, three aspects need to be considered: (i) the global population aged 60+ years is expected to grow from 841 million today to a total of 2 billion by 2050 (WHO, 2014); (ii) the growing older population is retaining more teeth, consequently, the older population at risk of developing caries and/or periodontitis is increasing dramatically; and (iii) relevant risk factors for periodontitis, such as diabetes, and medication-induced reduced salivary secretion or dementia for caries, are expected to increase as well. The prevalence of diabetes has "*near quadrupled*" since 1980 (N.C.D.Risk-Factor-Collaboration, 2016), with the number of diabetic adults expected to exceed 700 million by 2025 (N.C.D.Risk-Factor-Collaboration, 2016). The number of individuals with dementia is expected to rise from 46 million today to 132 million by 2050 (Prince et al., 2015). This needs to be taken into account for future workforce planning (Jager et al., 2016).

Recommendations for Surveillance

Demographic changes and the described trends of both diseases and their risk factors drive the need to learn more about the burden of caries and periodontal diseases in older populations. More research is needed to provide the foundation for better prevention and management in older populations. The following high-level priorities need to be implemented nationally and globally:

- National oral health surveys need to include representative samples of 65-74 year olds and 75+ year olds, with consideration for the very old (85 years and older) and frail and/or care dependent elders, and/or older people with multimorbidity and polypharmacy (for example by oversampling).

- In order to understand disease progression with age, future long-term longitudinal studies recording the disease extent and severity of both caries and periodontitis in these age groups, as well as a comprehensive set of risk determinants, are warranted.
- Epidemiologic evaluations in older populations should include oral hygiene levels, tooth loss, attachment level, pocket probing depths, and inflammation (bleeding on probing) as well as the presence and number of coronal and root caries lesions, their severity and activity, along with the number of restored teeth. Quality of life measures, salive secretion rates and (medical) risk factors should also be assessed.
- Reporting of surveys need to follow standardized formats in order to allow comparisons and data synthesis (Holtfreter et al., 2015).

Age-related changes in immune function (immune senescence) in caries and periodontal diseases

Relevance of immune function for caries

At present, there is not enough evidence about the relevance of immune function in caries, and more research on this topic is required. Given the importance of the bacterial biofilm to caries etiology, it is relevant to consider whether the immune system is responsive to the biofilm in the context of caries. It is known that certain elements of the innate- and adaptive immune system react to caries-associated bacteria, with the production of host antimicrobial peptides, changes in odontoblast Toll-like receptor (TLR) expression, production of neutrophil extracellular traps (NETs) in the gingival crevice, and production of secretory immunoglobulin A (sIgA) antibodies (Preshaw et al., 2017). More research is required to investigate if such host defences are part of homeostatic responses and to what extent they are relevant in caries initiation and progression.

Relevance of immune function in periodontal diseases

Evidence accumulating from a vast number of studies demonstrates the relevance of several elements of both the innate as well as adaptive immunity in the pathogenesis of periodontal diseases, including gingivitis and periodontitis. Periodontitis is a chronic inflammatory disease in which tissue damage results from dysregulated and prolonged inflammatory responses to the persisting subgingival biofilm. Moreover, aberrant or exaggerated immune/inflammatory responses against the microbial challenge have been implicated in the etiology of severe forms of periodontitis (Bartold and Van Dyke, 2013).

Evidence for immune senescence

Substantial evidence supports that immune function alters with increasing age, as evidenced by increased susceptibility to infections, increased autoimmunity, decreased effectiveness of vaccinations, and delayed wound healing and repair in older individuals as compared to younger individuals. There is also substantial evidence from human, animal and laboratory-based studies that cellular and molecular processes related to immune functioning and inflammatory responses alter with increasing age (Goronzy and Weyand, 2012, Boraschi et al.,

2013). Such changes include functional alterations in key immune cells such as neutrophils and macrophages, for example, relating to changes in cell surface receptor expression and signal transduction pathways, apoptosis, chemotactic accuracy and production of pro-inflammatory mediators that likely underpin observed changes in immune function with age (Preshaw et al., 2017). Such changes do not necessarily signify immune deficiency, but rather can be regarded as dysregulated immune responsiveness leading, in broad terms, to increased systemic inflammatory status in older individuals and that are associated with increased susceptibility to infection (Gomez et al., 2008, Hajishengallis, 2010).

Relevance of immune senescence for caries and periodontal diseases

Currently there is lack of evidence that immune senescence is relevant to caries pathogenesis or clinical manifestations and outcome of caries (Preshaw et al., 2017).

Although substantial evidence exists that immune senescence affects immune-inflammatory mechanisms that are relevant to the pathogenesis of periodontitis, it is yet to be established if this results in increased disease susceptibility and/or accelerated disease progression. Such mechanisms include, for example, altered neutrophil function, age-related decreases in NET formation, increased neutrophil persistence, increased secretion of pro-inflammatory cytokines such as interleukin-1β (IL-1β), IL-6, IL-17 and prostaglandin E_2 (PGE_2), and upregulated expression of genes that contribute to a pro-inflammatory state (Preshaw et al., 2017). Further human studies are required to investigate whether such age-related changes in immune functioning are linked to increased disease susceptibility.

Assessment of immune senescence in caries and periodontal diseases and potential health benefits for the prevention of caries and periodontal disease

Although markers for immune senescence in humans such as shortening of leukocyte telomere length, telomerase activity and changes in expression of T cell surface markers such as CD28 do exist (High et al., 2012), it is currently not possible to assess immune senescence or its potential sequelae in the context of caries and periodontitis. Future research should evaluate such markers and their relevance in caries and periodontal disease susceptibility and progression.

Common age-related immunological factors / conditions influencing both, caries and periodontitis

There is limited evidence to support the theory that immunological components are relevant to the pathogenesis of both caries and periodontitis. However, there is some evidence to suggest that there is an upregulation of Toll-like receptors (e.g. TLR-2 and TLR-4) and co-receptor CD14, as well as formation of NETs in ageing that might affect both diseases (Preshaw et al., 2017).

Prevention and treatment (management) of caries and periodontal diseases in older adults

Underlying evidence for prevention and treatment of caries and periodontal diseases (irrespective of age)

Prevention of periodontal diseases refers to reducing the development of clinically detectable gingival inflammation (gingivitis) that may ultimately progress to attachment and bone loss (periodontitis). Consistent evidence demonstrates that primary prevention strategies based on patient-performed control of the dental biofilm and routine professional mechanical plaque removal (PMPR) are effective in achieving an overall improvement in the levels of oral cleanliness, a decrease in gingival inflammation and a decrease in the prevalence of mild to moderate periodontitis (Eke et al., 2012, Tonetti et al., 2015). Also, routine PMPR as the fundamental component of supportive periodontal therapy has been shown to be efficacious in preventing progressive attachment loss and retaining teeth following active periodontal treatment of patients with periodontitis (Sanz et al., 2015). In addition, the control/management of risk factors for periodontitis such as smoking and diabetes forms an important part of prevention of periodontitis.

Available evidence supports successful treatment of periodontitis in retaining more teeth (Trombelli et al. 2015). Active periodontal treatment should aim to achieve low levels of bleeding on probing (<15% sites), shallow probing pocket depths (<5mm) and absence of suppuration (Sanz et al., 2015). Successful periodontal therapy is based on professional supra- and subgingival debridement which can be achieved either surgically or non-surgically (Needleman et al., 2002, Heitz-Mayfield and Lang, 2013). Patient adherence to both effective self-performed plaque removal (or assisted in the dependent individual) and recall attendance during supportive periodontal therapy, are key elements for success (Lee et al., 2015).

The management of dental caries involves a continuum of preventive and treatment strategies. Many of these techniques and therapeutic agents can be used for both, caries prevention and arrest of caries lesions (Meyer-Lueckel and Paris, 2016). The evidence base for caries

treatment and prevention is supported by a rich history of RCTs and Cochrane Reviews although much of this is based on studies involving adolescents and younger children (Table 1) and much less evidence exists on older and dependent patients as well as root caries. As there is a common etiology for caries in both coronal and root surfaces (Takahashi and Nyvad, 2016) it is likely that the same treatments that showed efficacy in coronal caries are also efficacious in root caries but often evidence is lacking. For example it should be recognized that exposed root surfaces might be more vulnerable to demineralisation than the coronal surfaces (Hoppenbrouwers et al., 1987) and thus more reseach is needed to identify most efficacious preventive and therapeutic treatments.

There is robust evidence suggesting that -fluoride-based therapies are efficacious. Evidence from younger patient cohorts in relation to coronal caries is mirrored by evidence examining fluoride use (i.e. high F-conc. varnish/toothpaste) in root caries in older adults (Griffin et al., 2007, Wierichs and Meyer-Lueckel, 2015). These have been found cost-effective as well (Schwendicke and Gostemeyer, 2016).

The provision of operative care for dental caries has been a mainstay of dentistry for over half a century. The use of modern adhesive technologies and the ability to restore teeth affected by caries is well described (Opdam et al., 2014)., if a non-operative approach is not (more) applicable. But also here most of existing scientific evidence refers to children and independent adults.

Age-dependent differences in efficacy of prevention or treatment of caries and periodontitis

The evidence suggests that ageing per se has no or very limited effect on the outcomes of prevention or treatment of dental caries or periodontal diseases (Trombelli et al., 2010, Axelsson et al., 1991, Lindhe et al., 1985, Heasman et al., 2017, Griffin et al., 2007). However, it is important to avoid complacency in preventive care and treatment as changes may occur in disease vulnerability in elders due to a variety of factors including illness and frailty, use of medications, reduced salivary secretion, widespread prevalence of (poor) fixed and removable dental prostheses and changes in vision, tactile sensitivity, cognitive- and motor function, including the ability to perform effective oral hygiene. An individualised oral health care plan is therefore especially important in vulnerable elders. For the same reasons, treatment of

caries and periodontitis may become technically more challenging in elders. There are indications for example that restorations in the elderly have a shorter survival time than in younger individuals (Stewardson et al., 2011, Gil-Montoya et al., 2014). Non-invasive/preventive approaches to caries and periodontal diseases should therefore be given high priority before considering (invasive) treatments (Schwendicke et al., 2015).

Impact of physical and cognitive impairment

For patients with limited mobility, access to care may be an issue, as transport has to be organised where mobile dental services are not available. The dental workforce required to provide such care is often scarce or lacking. Economic pressures and a lack of training and knowledge in dental care for the elderly may add to the shortage of available dental services. Patients with cognitive impairment show a higher prevalence of coronal and root caries, and present more often with root remnants, as the utilisation of dental services declines (Teng et al., 2016). Furthermore, patients with dementia have an increased likelihood of tooth loss and untreated caries (Ellefsen et al., 2009) and present with poor oral and denture hygiene (Syrjala et al., 2010). Dementia implies a shift in priorities along with the inability to accurately perform oral hygiene measures and an increasing dependency on primary oral care by others. Additional compliance problems are likely to occur in the final stages of the disease (Delwel et al., 2016). Combined with a shift in dietary intake towards more sweet food-stuffs the risk factors for developing caries lesions increases significantly. The risk of caries may be further increased as result of a decreased salivary secretion due to medications use (Aliko et al., 2015).

Integration of prevention and treatment of caries and periodontitis in an oral health care plan using a patient-centred care approach, taking into account the level of dependency in older adults

There is a need to adapt our approaches to the planning of care for elders. The key to this adaption will be an initial assessment of the patients' level of dependency, including their medical condition and physical and cognitive impairment. Uncomplicated approaches to assess the individual's level of dependency in the activities of daily life, such as the use of the Rockwood scale (Rockwood et al., 2005), are useful tools to guide clinicians and caregivers, rather than simply using chronological age in the planning and delivery of appropriate care. The following elements may also need to be considered (Ettinger, 2015):

- the patient's desires and expectations
- the type and severity of dental needs
- the presence of other diseases and its progression (of the disease) and its interactions on oral health
- the presence of medication use (polypharmacy)
- the remaining life expectancy
- the impact on quality of life
- the probability of positive outcomes
- reasonable treatment alternatives
- the ability to tolerate the stress of treatment
- the capability to maintain oral health
- financial and other resources
- the dentist's capabilities

Care pathways are designed to guide practitioners along an evidence informed approach to delivering care in a manner that provides a predictable outcome. One example is the Seattle Care Pathway for older adults which provides a means by which patients at different levels of dependency (from pre-dependant through to highly dependent) can be assessed and dental care plans derived that account for prevention and treatment encompassing all elements of the patient-centred approach (Pretty et al., 2014).

Adaptation may involve not only a rationalisation of "ideal" treatment planning but may also include the provision of therapies that may not be widely used in the general population. Examples include the use of assisted brushing, use of the Atraumatic Restorative Treatment technique (ART) for the restoration of caries lesions (da Mata et al., 2015).

A oral health care plan must be part of the total care plan and should include both professional and self-care elements. It is important that both elements reflect the previously mentioned assessments and the recognition that self-care (oral hygiene) may also be delivered by others than dental professionals, such as other carers or family members. The preventive components of both professional care and self-care must reflect the medical and oral risk profile of the patient and their clinical status (De Visschere et al., 2006).

The professional element of dental and periodontal treatment in elders may be delivered by a range of oral health care team-members. Where available, consideration should be given to the wider use of different members of the dental team, for example dental hygienists/therapists, in order to ensure that care is delivered by an efficient workforce in a cost effective manner (Brocklehurst et al., 2012).

The challenge of provision of services to older adults should be recognised by policy makers in both health and social care areas. Dental education providers should ensure that students have knowledge and competence in the treatment of older adults at different levels of dependence (Wolff et al., 2014).

Call to action to protect and enhance oral health and wellbeing as an essential component of healthy aging

Good oral health and comfort is an integral part of healthy aging. Demographic transitions, trends in risk factors and medical co-morbidities, better prevention and management of caries and periodontal disease earlier in life leading to tooth retention, all point to an urgent need for system-wide measures to align policy, practice, education and public information about changing oral health needs for the aging population. Preservation of a functional dentition into old age is possible and may be associated with better overall quality of life and delayed frailty and dependence. Specific actions need to be implemented with input from relevant stakeholders and adapted to different health systems.

Public health/policy

1. Dental care professionals should be an integral part of medical and social health teams involved in care of elders. Routine sharing of relevant health information will be necessary in order to achieve this goal.
2. Policy makers should plan for the increasing oral health care needs of the ageing population. Specific actions are needed to overcome barriers in the care for vulnerable elders.
3. (Health) care organizations and long-term care facilities should integrate assisted daily oral care in the professional profile of caregivers, as well as provide access to dental care.

Oral health care practitioners

1. Since preventive measures and treatment strategies are effective at all ages, the oral care team should be encouraged to provide the same standard of prevention and care across the whole age range (whenever possible without consideration of age) .
2. Where ageing is associated with a change in dependency including medical status, dental care should be modified with the aim of retaining a pain-free, functional dentition, using appropriate (minimally invasive, also palliative) treatment strategies.

3. Consider medical aspects when treating oral diseases and collaborate with physicians and other caregivers.
4. Consider mobility needs of elders in your practice.

Researchers and Funding Agencies

1. There is an urgent need for epidemiological surveillance of caries, periodontal diseases, tooth loss and oral health related quality of life in older populations.
2. Research priorities should be placed on how preventive and therapeutic regimens may preserve oral health, quality of life and nutrition into older age as comorbities present unique challenge to the delivery of intrinsically efficacious and effective strategies.

Educators

1. Consider the changing epidemiology and demography as well as the changing needs of older adults while developing and delivering both knowledge- and competence-based curricula at undergraduate, post-graduate and continuing education of oral health care professionals.
2. Strengthen knowledge and increase awareness of medical comorbidities and medications relevant to the oral care of older adults.

Caregivers and relatives

Be aware that:

1. Chewing is an essential function to ensure adequate nutrition and is best preserved with natural teeth.
2. Oral health is a critical component of healthy aging and requires ability in self-care and access to preventive services and treatment.
3. As older subjects become more reliant on the care of others for their daily life activities, so do their needs increase for the preservation of oral health and chewing function.
4. Physical and mental health decline associated with aging have a great impact on the ability to perform oral self-care and there is a caregivers need to overcome the barriers to care.

Public

1. Teeth are for a lifetime. Keeping your teeth is possible as you age and important for eating, speaking, smiling and feeling good about yourself.
2. Look after your teeth and gums. Brush your teeth twice a day with fluoride toothpaste and clean in between your teeth with interdental brushes as advised by your dentist. Refrain from frequent consumption of sugary foods and sweet drinks as much as possible and limit their consumption to meal times only.
3. If you have difficulty in cleaning your teeth and gums, ask your carer for help.
4. See your dentist/oral care professional for preventive care for tooth decay and gum disease and necessary treatment.

Conclusions

1. Epidemiologic evidence and analysis of trends in risk factors suggest that the burden of caries and periodontal diseases will increase in aging populations that tend to retain more teeth. This requires urgent action.
2. Effective preventive and therapeutic interventions are available to manage both caries and periodontal diseases. These should be applied to retain natural teeth and dentitions into older age.
3. Level of dependence, rather than chronological age, needs to be considered in order to individualize preventive and treatment approaches in older subjects.
4. Benefits related to retention of healthy dentitions and mastication go beyond oral health, wellbeing and self-esteem as they foster a healthy diet which is necessary to delay physical decline and loss of dependence.
5. Increased attention to the oral health needs of an aging population urgently requires combined efforts by relevant stakeholders.

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Table

Studies providing evidence for the efficacy of fluorides on dental caries

Mode of delivery of fluoride	Reference	Study population	Main outcome	Pooled PF (CI), p-value, heterogeneity (I^2)	Quality of evidence, summary
Toothpaste	(Marinho et al., 2003)	42 300 children <16 y	Caries increment [Δ D(M)FS]	24% (21-28), p<0.001 Clear heterogeneity (p<0.0001)	Relatively high quality. Provides clear evidence that fluoride toothpastes are efficacious in preventing caries.
Mouthrinse	(Marinho et al., 2016)	15 305 children <16 y (permanent teeth)	Caries increment [Δ D(M)FS] [Δ D(M)FT]	27% (23-30), I^2=42% 23% (18-29), I^2=54%	Moderate quality of evidence. Supervised regular use of fluoride mouthrinse by children and adolescents is associated with a large reduction in caries increment in permanent teeth
Water fluoridation	(Iheozor-Ejiofor et al., 2015)	44 268 children (deciduous dentition) 78 764 persons (permanent dentition)	Caries increment Δ dmft % caries free Δ DMFT % caries free	dmft: 1.81 (1.31-2.21), 35% % caries free: ↑15 (11-19) DMFT: 1.16 (0.72-1.61), 26% % caries free: ↑14 (5-23)	Available data come predominantly from studies in children conducted prior to 1975. Water fluoridation is effective at reducing caries levels in both deciduous and permanent dentition in children. No evidence is available to determine the effectiveness of water fluoridation for preventing caries in adults.
Topical fluoride gel	(Marinho et al., 2015)	8479 children <16 y 1254 with primary teeth only	Caries increment [Δ D(M)FS] [Δ d(m)fs]	28% (19-36), p<0.001, I^2=82% 20% (1-38), p=0.04, I^2=0%	Moderate quality evidence of a large caries-inhibiting effect of fluoride gel in the permanent dentition. Low quality evidence of a large effect in only 3 trials
Topical fluoride varnish	(Marinho et al., 2013)	9 595 children <16 y	Caries increment [Δ D(M)FS] [Δ d(m)fs]	43% (30-57), p<0.001 37% (24-51), p<0.001	Substantial caries-inhibiting effect of fluoride varnish in both permanent and primary teeth. Moderate quality evidence: mainly high risk of bias studies, with considerable heterogeneity.
Topical varnish, gel, mouthrinse in combination with toothpaste	(Marinho et al., 2004)	4 026 children <16 y	Caries increment [Δ D(M)FS]	10% (2-17), p=0.01 (in favour of the combination), I^2=32%	Topical fluorides (mouthrinses, gels, or varnishes) used in addition to fluoride toothpaste achieve a modest reduction in caries compared to toothpaste used alone.

Please note that the studies in shown this table analysed the caries preventive efficacy of fluoride in differend modes of delivery in children – not in older patients. Therefore, results should be interpreted with caution and cannot be transferred offhand to an older population and root caries.
DMFT = decayed, missing, filled teeth (permanent teeth); DMFS = decayed, missing, filled surfaces (permanent teeth)

dmft = decayed, missing, filled teeth (deciduous teeth); dmfs = decayed, missing, filled surfaces (deciduous teeth)
PF = prevented fraction, CI = confidence interval

Figure: Authors