The Economist INTELLIGENCE UNIT

Time to take gum disease seriously

The societal and economic impact of periodontitis

COMMISSIONED BY EFP European Federation of Periodontology SPONSORED BY Oral-B

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Executive summary

Periodontal (gum) diseases are strikingly common across the globe, but also largely preventable. Left untreated, they are the main cause of tooth loss and considered one of the main threats to oral health. In Western Europe, a region which offers some of the most advanced healthcare services to the general public, developments in the prevention and management of periodontitis appear stagnant. The prevalence of periodontitis has remained largely unchanged over the last 25 years. The evidence-base shows periodontitis, which is the severe form of gum disease, has associations with diabetes, cardiovascular diseases and over 50 non-communicable diseases. Recognition of these mutual risk factors and knowledge sharing between dentistry and general health are scarce in clinical practice. Similar to general health, poor oral health is also strongly associated with lower socioeconomic status. Unlike accessing the General Practitioner (GP), which in most of Western Europe are free at the point of access, many report avoiding dental check-ups due to the upfront costs. This avoidance only exacerbates poor oral health in socio-economically deprived neighbourhoods.

Given the prevalence and preventable nature of periodontitis, new ways of thinking about gum health are needed to increase awareness and action at national level. This Economist Intelligence Unit (EIU) report aims to capture the attention of policy makers in six European countries (France, Germany, Italy, the Netherlands, Spain and the United Kingdom), emphasising the economic and societal benefits of action and inaction in the early treatment of periodontitis.

To improve early detection and prevention of periodontitis, this report arrives at the following recommendations:

Prevention, diagnosis and management of periodontitis is cost-effective. First and foremost, the role of home care led by patients is of paramount importance to prevent gingivitis and periodontitis. Our economic analysis shows that both eliminating gingivitis (the precursor to periodontitis) using home care prevention techniques (such as tooth brushing and interdental brushing) and increasing the rate of diagnosis and management of periodontitis to 90%, has a positive return on investment in all of the European countries in this study. Making efforts to eliminate gingivitis, thus preventing progression to periodontitis, would save considerable costs over a 10 year time period compared with 'business as usual' (36Bn Euros in Italy to 7.8Bn Euros in the Netherlands). Neglecting to manage gingivitis can significantly increase costs and reduce Healthy Life Years (HLYs); therefore an emphasis on self-care and prevention is critical from both an individual and a societal perspective.

Better integration of dental and general healthcare. The value of integrating these systems in practice is still developing. Being able to share information across disciplines may both improve patient care due to the common risk factors shared between some dental and physical health conditions and contribute significantly to dental/general health research. Integration may also encourage shared responsibility across healthcare disciplines to address unmet oral health needs in vulnerable and marginalised communities.

A synergy of societal and individual public health campaigns are needed. One without the other would exacerbate oral health inequalities which we see both within and across countries. Societal level prevention is of crucial concern to the prevention of periodontitis, especially as it is a disease highly prevalent in deprived areas. Individual public health campaigns need to pay special attention to less affluent communities and embed prevention and early intervention into community settings such as schools (for the prevention of caries) and health centres (for the prevention of gum disease).

Improving the affordability of dental care. The cost of accessing a dentist is a barrier to receiving treatment early for many of the general public. Because of these costs, people are more likely to access the dentist when there is something wrong rather than for check-ups or preventative treatment which is essential for avoiding periodontitis. Although dental care appears 'free on paper' in countries such as the UK and France, only part of the dental procedures for treating periodontitis are covered and the remainder is paid for out-of-pocket. In countries such as Spain and Italy, most if not all periodontitis treatment is paid for out-of-pocket or via private insurance. Periodontitis treatment for a low-income family is therefore rendered almost unaffordable. In this study we have provided the evidence that professionally-managed periodontitis is in fact cost-effective and therefore publically covered dental care for periodontitis deserves a review from policy makers and commissioners Europe-wide.

About this report

This report describes the methods and main findings from The Economist Intelligence Unit's research which assesses the evidence linking improved periodontal health to better overall health outcomes, and showcases the economic and societal implications associated with periodontal health across six European countries: France, Germany, Italy, the Netherlands, Spain and the United Kingdom. These countries were selected for their geographic, demographic, epidemiologic, and socioeconomic comparability.

The report presents the results of a literature review and an economic return-on-investment model for preventing and managing periodontitis, analysed for each country separately. To supplement the information found in the published literature, we conducted interviews with experts, extracts of which are displayed in italics throughout the report. To note, the findings and views expressed in this report are those of the EIU. We extend our sincere appreciation to the following for their time and contributions to this work:

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- **Dr Nigel Carter**, Chief Executive of the Oral Health Foundation, UK.
- **Dr Pierpaolo Cortellini**, Founder and board member of the European Research Group in Periodontology, Private Practice, Italy.
- **Professor Thomas Kocher**, Director of the Periodontics unit; Chairman of the Department of Restorative Dentistry, Periodontology, Endodontics, Preventive Dentistry and Periodontics at the Dental School of Greifswald, Germany.
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- **Professor Bruno Loos**, Professor in Periodontology at the Academic Centre for Dentistry Amsterdam (ACTA); Director of Research at ACTA.
- **Professor Wagner Marcenes**, Professor in Oral Epidemiology, Chair of AHi (affordablehealthinitiative.com).
- **Professor Jose Nart**, Professor, Chairman and Program Director, Department of Periodontology, UIC-Barcelona, Vice President of the Spanish Society of Periodontology and Osseonintegration.
- **Professor Ian Needleman**, Professor of Restorative Dentistry and Evidence-Based Healthcare at UCL Eastman Dental Institute; Honorary Consultant in Periodontology with UCLH, in specialist practice at PerioLondon.
- **Professor Panos Papapanou**, Professor of Dental Medicine; Chair of the Section of Oral, Diagnostic and Rehabilitation Sciences; Director of the Division of Periodontics, Columbia University College of Dental Medicine.

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- **Sharon Legendre**, Head of Operations at the European Federation of Periodontology.
- **Professor Nicola West**, Professor of Periodontology, Head of Clinical Trials Unit, Consultant in Restorative Dentistry Bristol Dental Hospital UK.

Introduction

> **You would not ignore bleeding from your eye, so why would you ignore bleeding from your mouth?**
>
> Professor Maurizio Tonetti,
> Executive Director of the European
> Research group on Periodontology.

Periodontitis may not be the first disease that comes to mind when thinking about global public health problems, but periodontal disease, consisting of both gingivitis and periodontitis, is in fact the most common global disease, alongside dental caries.[1] Periodontitis manifests across a spectrum of severity ranging from inflammation to disability. It is caused by inflammation of the gums and underlying bone due to build-up of dental plaque. Symptoms range from bleeding and discomfort, to periodontal ligament loss and deterioration of the bone which holds the teeth in place. This can result in loss of chewing function, speaking function, inability to smile and ultimately, relate with others.[2]

Although treatable in a majority of cases, if left untreated, periodontitis is the main cause of tooth loss and is considered one of the main threats to oral health in adults.[3] It is also a threat to general health, as severe periodontitis, along with caries, tooth loss and other oral conditions are responsible for more years lost to disability than any other human disease,[4] notably due to its association with systemic diseases like diabetes and cardiovascular diseases, and causing physical discomfort. Periodontitis is sometimes referred to as a "silent disease"[5] due to its slow and gradual progression and its mild early symptoms.[6]

This is a misnomer. Rather than silent, periodontitis is misinterpreted, as its awareness among the general public, dentists, and other health professionals remains low. Studies show three out of four adults with periodontitis do not know they have a condition at all.[7] While most general dental practitioners can manage uncomplicated periodontitis, gaps in advanced services exist.[8]

This study captures the socioeconomic burden of periodontitis in two ways. In tangible, quantitative terms using an economic model and through exploring existing policies and periodontitis practices, in addition to interviews with dental experts. In doing so, we hope to pave the way for a spotlight on periodontitis prevention policies across Europe, highlighting disparities in best practices and proposing key recommendations moving forward.

Ultimately, this study seeks to reach four key aims:

1. Evaluate the prevalence of periodontal disease and review current policy
2. Explore the integration of general health with dental health to better manage periodontitis
3. Understand the impact of individual and societal level oral health prevention techniques to pinpoint potential improvements
4. Compare economic and societal costs and benefits of action and inaction in the treatment of early periodontitis.

Chapter 1: A spotlight on periodontitis and gum health

Very early periodontitis is often undiagnosed and causes various problems later in life such as developing severe periodontitis. Severe periodontitis is the real public health problem, it does not only affect the health of the gums, it has implications to the general health of the patient and their well-being.

Professor Mariano Sanz, Professor and chair of periodontology, University of Madrid, Spain.

Periodontitis fulfils Aubrey Sheiham's (a dental epidemiologist) criteria of a public health issue, due to its high prevalence, its impact on individuals and on society, and the fact that it remains preventable and treatable.[9] Clinical definitions of periodontitis vary which has downstream consequences on the ways in which the disease is measured in the population.

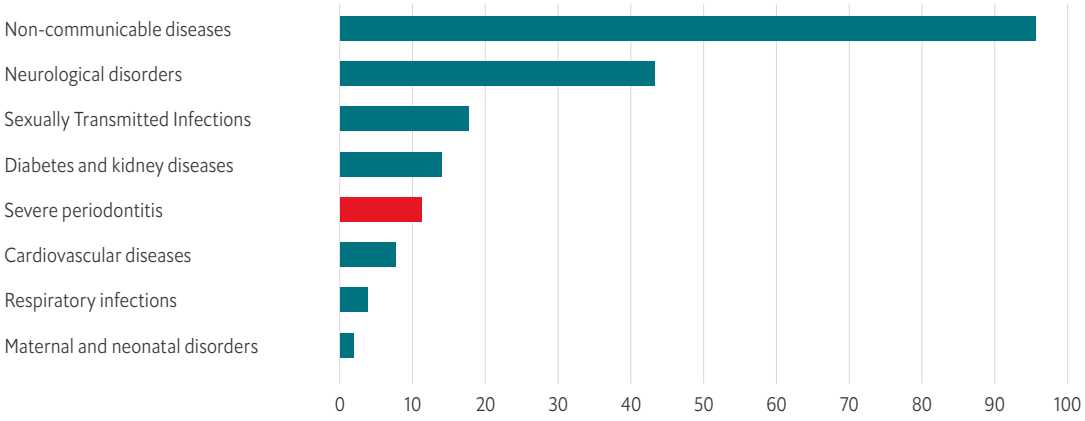
Prevalence estimates can be over- or underestimations,[10] but on the whole, the available data indicates periodontitis is both persistent and of high prevalence.

"It is important to consider when determining the impact of periodontitis as a public health problem to understand the proportion of the population affected compared to other health conditions". Professor Panos Papapanou, Director of the Division of Periodontics, Columbia University College of Dental Medicine.

Periodontitis is the sixth-most prevalent health condition globally. According to the Global Burden of Disease (2017) the prevalence of severe periodontitis was 11% affecting approximately 743 million people. Compared to some other common diseases, it is almost on par with the prevalence of sexually transmitted infections (16%) and is more common than cardiovascular disease (prevalence 6.6%).[4] The prevalence of milder forms of periodontitis are staggeringly common, affecting at least half of the global population.[11,12]

Prevalence of the main causes of global diseases for 195 countries and territories in 2017 [4]

(%)



Across the six countries included in this analysis, prevalence has remained fairly stable over a 20-year time-period, but contrasts remain between countries in Europe. For example, in 2010 the prevalence of periodontitis in Spain stood at 4.3%, lower than the global average of 11%, but was relatively higher in Italy, at 13.1% (Table 1). There is also a clear pattern with age – more people have periodontitis when they are older.

Table 1 shows higher prevalence among people aged 65-74 compared to ages 35-44 in all countries where data is available. Reliable and comparable prevalence data is, however, difficult to come by,[11] with the best estimates coming from the Global Burden of Disease (GBD) study which covers severe cases only.[10]

Table 1: Prevalence and incidence of severe periodontitis in Europe.

Country	Prevalence of severe periodontitis per 100 population (GBD data)[10]		Prevalence of all periodontitis patients (Using community periodontitis index scores of 3 and 4) aged 65-74 as a % of the population	Prevalence of all periodontitis patients (Using community periodontitis index scores of 3 and 4) aged 35-44 as a % of the population	Alternative sources. Prevalence of severe and moderate perio in people ages 20-75.	Alternative sources. Prevalence of all perio in a random sample of people who's average age was 58
	1990	2010	Multiple dates	Multiple dates	2015	2013
France	7.1 (6.0-8.4)	6.9 (5.7-8.3)	32% (2017)[13]	No data		
Germany	11.6 (10.0-13.3)	11.2 (9.6-12.9)	80.2% (1997-2001)[11]	73.2% (2005)[11]		
UK	6.6 (5.6-7.6)	6.4 (5.4-7.4)	60% (2009)[11]	43% (2009)[11]		
Spain	4.4 (3.5-5.4)	4.3 (3.4-5.3)	38% (2005-2006)[11]	25.4% (2005-2006)[11]		
Netherlands	11.0 (4.8-22.3)	10.5 (4.6-20.9)	No data	No data		16.2%[14]
Italy	13.6 (11.6-15.7)	13.1 (11.2-15.3)	No data	No data	34.95% severe[15] 40.78% moderate[15]	

> **In Germany, about 30-40% of all extracted teeth are done so because of periodontal disease, and this seems to be unchanged for the last 15 years.**
>
> Professor Thomas Kocher, Director of Periodontics, Dental School of Griefswald, Germany.

Despite improvements in the quality of oral health services in Europe and increased awareness of the importance of oral hygiene,[16] the data suggests these have had little impact on the prevalence and incidence of periodontitis. In most European countries, the proportion of the population reporting unmet needs remains significantly higher for dentistry than for general medical care. Around 8% of people in Portugal, Latvia and Greece reported unmet needs for dental care in 2018.[17] A survey carried out in Portugal, Romania and Sweden showed that 74.9% of adolescents were not aware of the fact that tooth brushing can prevent periodontal disease.[18] The available evidence indicates an urgent need for heightened awareness of the burden of periodontitis, to improve both prevention policies and access to care.

Risk factors of periodontitis

Increasing age is a well-documented risk factor for periodontitis. A steep increase in prevalence is shown in 30 and 40-year-olds[19] and is generally highest in 65 to 74 year olds.[11] Only 1.7% of cases are among younger populations.[20] As the European population continues to age, the demand for periodontal detection and treatment rises, making it crucial to design more effective prevention strategies and trigger efficient policy responses.

Periodontitis is often labelled a 'social disease', stressing its sensitivity to inequalities and behaviour.[21-23] Less stringent dental care routines, poorer access to dental practices, and less frequent attendance at preventative dental check-ups are associated with living in disadvantaged areas.[23] Periodontitis prevalence is clustered amongst socioeconomically deprived groups across Europe,[7] such as people living in poverty, ethnic minorities and isolated older adults who have poor access to dental care. The disparities in dental outcomes and care access between affluent and deprived communities are so severe that a social-determinants-of-health approach must be part of the process to improve outcomes.[24]

Lifestyle choices also have a direct impact on the prevalence of periodontitis, and are mainly modifiable behaviours. Several studies have consistently reinforced that smoking and poor diet are critical risk factors for periodontal disease.[4,12] Directly modifying behaviours, therefore, is a simple yet powerful policy message for mitigating periodontitis.

The periodontal pathway of care

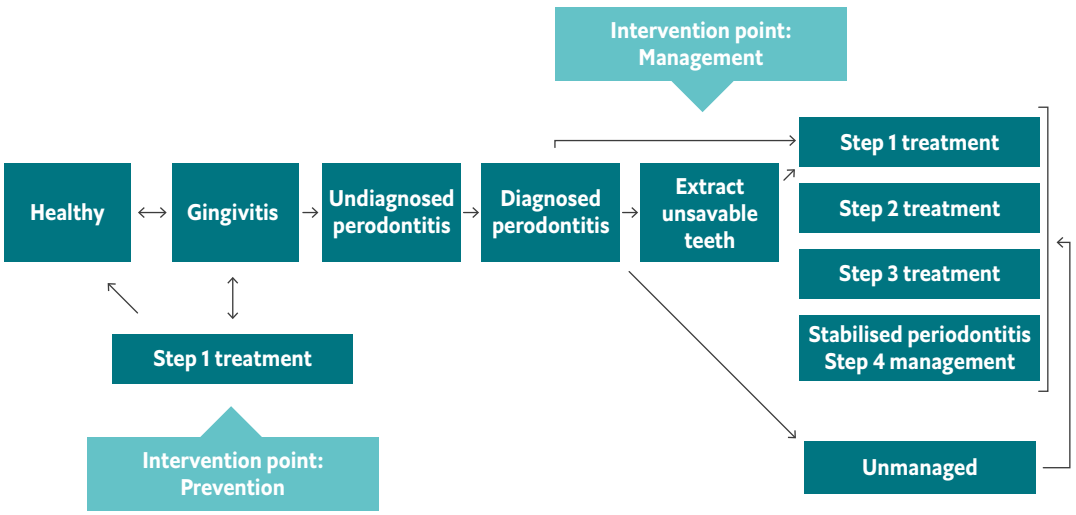
Knowing if you have gingivitis or periodontitis requires an oral health assessment and diagnosis. Around 90% of people have gingivitis globally, which is a superficial inflammation that presents as bleeding gums.[25] Gingivitis if not managed can progress to periodontitis, which is a deeper-seated gum inflammation that destroys the bone that holds the teeth in the jaws. The presence of gingivitis is both a warning sign and the primary intervention point for the prevention of periodontitis. Periodontitis also presents with bleeding gums and the damaged caused is irreversible, but can be stabilised such that teeth can be retained.

Both gingivitis and periodontitis are preventable and also treatable. The primary care general dental practitioner has the capacity to diagnose and manage 95% of periodontal cases.[3] Treating gingivitis prevents the development of periodontitis and is simple to achieve in most people. The mainstay of treatment is reducing dental plaque build-up on teeth at and below the gum line. The role of home care by patients is of paramount importance to prevent gingivitis and periodontitis, but requires training and instruction from the dental team, including specially trained dental nurses, dental hygienists or dental surgeons. Treating periodontitis is more complex and costly, however the role of patient-delivered home care, with meticulous tooth brushing and interdental brushing remains the most important aspect of treatment. Successful management of periodontitis has also been shown to benefit general health and well-being.

The pathway for treatment and prevention of periodontitis should be life-long, patient-centered and composed of incremental steps[3,26] (see Figure 2). This pathway of care is two-fold. It starts with an initial diagnosis aimed at staging and grading the severity of the periodontal disease,[27] followed by sequential management of the disease, which aims to regenerate bone and reverse gingival inflammation.[28]

The official European treatment guidelines for periodontitis are split into 4 steps (Figure 2).[3] If prevention is not achieved and periodontitis is diagnosed, the first step of management involves informing the patient of the diagnosis and providing personally-tailored treatment options with support on behaviour change to ensure optimal oral hygiene and risk factor control. The second step of treatment aims to address the causes of the disease by controlling, and ultimately reducing the accumulation of plaque and calculus. If the endpoints of therapy have not been achieved through the second step, the third step may include surgery. Any successfully treated periodontitis patient remains a periodontitis patient for life and undergoes supportive periodontal care. This last stage aims to maintain periodontal stability by combining therapeutic and preventive methods, since periodontal disease can progress if maintenance is sub-optimal and risk factors are not controlled.[3]

Figure 2: The periodontal pathway of care.



Chapter 2: Filling the gaps - A societal approach to good oral health

Oral health and general health

Periodontitis can increase the risk of type II diabetes and cardiovascular disease, the inflammation is chronic. Having periodontal inflammation is more than a cosmetic issue, the patient's well-being is very much involved.

Professor Philippe Bouchard, Professor and Chairman of Periodontology, U.F.R. d'Odontologie, France.

While periodontitis is an urgent public health issue in and of itself, a growing body of evidence associates periodontitis with other systemic diseases. These associations occur via shared underlying pathways and exposure to common risk factors, such as age, socio-economic status and lifestyle choices. Periodontitis may also be a risk factor for many systemic conditions due to the presence of bacteria in the bloodstream and pro-inflammatory proteins which can affect other parts of the body.[4,29]

The evidence for these associations is strongest for diabetes and cardiovascular disease (CVD). There is a developing body of evidence that suggests periodontitis patients often exhibit symptoms of coronary artery disease.[30,31] Some studies have found that periodontal disease is likely to cause a 19% increase in risk of cardiovascular disease, which increases to a 44% increased risk in people aged 65 and over.[8] Bidirectional links between periodontitis and diabetes have also been established, meaning people with type 1 and type 2 diabetes are at greater risk of developing periodontitis, just as people with periodontitis are at greater risk of developing type 2 diabetes.[12]

Beyond CVD and diabetes, emerging evidence links periodontitis with cognitive decline,[32] Alzheimer's disease[33] and dementia.[34,35] Some authors suggest that periodontitis is a risk factor for cognitive decline;[35,36] others report that people with cognitive decline simply suffer from inadequate oral health, stemming from a loss in functionality, and are therefore more likely to develop periodontitis.[34]
An association between periodontal disease and various adverse pregnancy outcomes has been reported.[37-40] There are also tentative links with other conditions such as cancer,[41] rheumatoid arthritis[42] and respiratory disease.[43]

While further research is needed to study these links in detail, there is sufficient evidence highlighting the need for more integrated care pathways between dentistry and general health, breaking down the traditional silos and advising patients diagnosed with periodontitis of the risks to general health and vice versa.

Integrated general health and dental health care pathways

> **There is a split between the way medicine is delivered and the way dentistry is delivered. The two don't talk to each other. In the UK for example, although dentistry and medicine are all under the same roof of the NHS, there is no integration between dentistry and doctors. You can refer from dentistry to secondary care but there is no joined up thinking.**
>
> Dr Nigel Carter, Chief Executive of the Oral Health Foundation, United Kingdom.

In the periodontal treatment pathway, there are opportunities to integrate general health check-ups with oral health examinations. Better management of oral health could lead to better management of comorbidities, and thus lower overall health costs. This means the traditional segregation between dental and general medical practice would greatly benefit from being integrated in some way.

Dental treatment and preventative advice are mainly delivered in the dental chair, meaning that patients are consumers of a service rather than being actively engaged in a preventative approach.[44] Clinical treatment teams could better adopt a dual role in providing dental treatment, but also advising patients on how they can make choices that improve and maintain their general and oral health in synergy. Costs could also be saved by reducing the need for duplication of prevention advice, and the number of contacts with different health professionals, by creating clinical pathways that complement both dental and general medicine.[45]

Using the link between diabetes and periodontitis as an example, an integrated care pathway could look as simple as ensuring that patients with diabetes are sign-posted to a general dental practitioner for periodontal screening. In addition, patients attending a dental check-up could expect an oral health needs assessment, a clinical examination, screening for periodontitis and if periodontitis is diagnosed, an awareness-raising exercise about the risk of diabetes.[8]

Many pilots and operational systems exist, showcasing how integration between general and oral health can work. Yet there are still lessons to be learnt in terms of better managing comorbidities. For example, in Europe, the NHS has conducted research and drawn networks of communication between general and dental health and aims to have all parts of England served by an integrated care system from April 2021.[46] While these networks have proven to be pioneering exercises, in practice they have encountered many barriers to success, such as the cost of dentistry (reported as too ambiguous or high) and failing to systematically address patients' and community's needs. Further, the German Diabetes Association (DDG) is working on checklists for general health practitioners which include oral care considerations.[47]

> **There is very limited access to integrated electronic health records for dentists to review health information which would make it very easy to exchange information between oral and general health care providers.**
>
> Professor Stephan Listl, Quality and Safety of Oral Health Care, Radboud University, The Netherlands.

The increasing recognition of oral health as a key contributor to overall health, has encouraged the need for linking oral health data to general health data electronically to determine if certain dental services are associated with other types of health outcomes.[48] Very few examples of integrated electronic dental and medical records exist, despite dentists and physicians agreeing that sharing information in this way would be extremely useful.[49]

The importance of home care led by the individual

> **Despite efforts to improve dental health promotion, many people only visit the dentist when there is a tangible problem, not for check-ups which have a preventative focus.**
>
> Professor Mariano Sanz, Professor and chair of periodontology, University of Madrid, Spain.

The success of both gingivitis and periodontitis treatment heavily depends on individual levels of engagement and the potential for behaviour change. There is widespread consensus that self-performed oral hygiene is one of the most important factors in the prevention of periodontitis.[50-52] Despite this, how to effectively look after your teeth is not clearly understood and littered with conflicting guidelines such as the '2-minute myth'. Brushing twice daily for two minutes is only enough for very low-risk patients, it does not apply to high risk patients such as those with gingivitis, and early stage periodontitis.[53]

Daily effective plaque removal is key to prevention and is often more important to periodontal health than professional mechanical plaque removal by the clinical team. Evidence shows there is a benefit to rechargeable powered brushes over manual ones in the long-term.[25,95,96] Daily interdental cleaning is essential to ensure control of plaque and prevent periodontitis, combined with chemical anti-plaque agents such as mouth rinse and fluoridated toothpaste.[3] The costs of alternative interventions – such as laser, statins or probiotics – are not supported by enough evidence to justify their costs, therefore are paid for out-of-pocket at the patient's discretion.[3] While antibiotics and antiseptics (e.g., chlorhexidine mouth rinses) may be effective for a limited period of time, routine use is not recommended.[54]

Professor Ian Needleman of UCL Eastman Dental Institute, has been working on an approach to the periodontitis treatment pathway called the 'Expert Patient' model, which grants even more importance to the role of prevention at individual level. The Expert Patient model is usually used in the management of long-term conditions but might have relevance for the management of periodontitis.

The expert patient learns about their condition and ways to self-manage it, remaining engaged enough in their treatment to be considered experts in managing their disease and emerge as key decision makers in the treatment process.[55] Professor Needleman states "The idea of the expert patient is that the individual learns about their health, and how to manage their condition from a 'coach', in an environment where they feel comfortable, which might be during physical activity or faith groups."

Dental public health

Inequities in oral health exist between not just within countries. This is because we are in the middle of a transition where low-income countries and people experiencing poverty in high- middle- income countries are consuming a lot more tobacco and unhealthy foods than their counterparts. To tackle population inequities and the burden of oral diseases, which includes periodontitis, policy makers must consider hygiene habits, without neglecting the socio-economic and socio-psychological determinants of lifestyle and health.
Professor Wagner Marcenes, Oral Epidemiologist, Chair of the Affordable Health Initiative, United Kingdom (UK).

Social determinants are of crucial concern to the prevention of periodontitis, a disease especially prevalent in deprived areas.[56] Individuals with lower incomes and socioeconomic status have poorer health outcomes in general, which also applies to dental health. People with lower incomes experience increased tooth loss and have a higher prevalence of oral diseases.[57,58] Interventions to promote greater periodontal health need to recognise the particular social, cultural and environmental contexts in which prevention takes place. A best practice example is the dental caries prevention model.[58-61] If individuals have lower incomes, their children are more likely to suffer from early childhood caries.[59] Dental caries is the most prevalent preventable condition in children, especially among children living in deprived areas.[60,61]Research shows that preventative interventions are most effective when they combine both universal treatment delivered by healthcare professionals, with targeted prevention programmes delivered in relevant and existing community settings.[62] For example, nursery-based care, the establishment of community-based dental health support workers[63] and parental-supervised tooth-brushing from an early age,[64] have all contributed to successfully reducing dental caries in young children. Professor Wagner Marcenes, is an Oral Epidemiologist, and the chair of the Affordable Health Initiative,[65] which aims to integrate oral health with other healthcare services delivered to primary schools. Professor Marcenes, Oral Epidemiologist states:

"When we talk about prevention, we talk a lot about poverty and inequalities being one of the main barriers, which is true, but this is also something that is out of the hands of individual dentists and doctors, so we also support protective factors such as sealing cavities in children which is a cheap and effective procedure."

The prevention efforts from the Affordable Health Initiative[66,67] do not solely provide dental support. Professor Marcenes and team believe that education has a greater impact than treatment when preventing healthcare concerns; therefore parents, schoolteachers and children all attend health-promotion classes based around self-esteem, healthy food and prevention. The Affordable Health Initiative currently runs in five schools in Brazil and is applying for funding to run the initiative in poorer communities in the UK.

As well as a synergy of dental and general medical care and an emphasis on self-performed periodontal care, the dental public health community aims to advocate for the importance of integrated care in dentistry more broadly. One of the main reasons for the siloes which still dominate dental practice include challenges in generating evidence which proves the efficacy for more complex upstream interventions. Upstream interventions are policies that tackle oral health inequalities at the structural level, focussing on the social determinants of health and the risk factors shared between oral diseases and other non-communicable diseases (NCDs).[68] Because oral diseases share risk factors with some NCDs, such as sugar consumption, tobacco use and excessive alcohol use, oral health should be placed higher on the global NCDs agenda than it currently is.[24]

The commercial as well as the social determinants of health require equal concern and have particular relevance to dentistry. Commercial determinants of health are the strategies used by the private sector to promote products and choices that are detrimental to health. The WHO has recognised the clashing business interests of powerful economic operators and public health efforts to prevent non-communicable diseases, as one of the biggest challenges facing health promotion.[69] The sugar industry is a prime example of the commercial determinants of health working against oral health.[70] Sugary drinks are one of the major sources of sugar in the global diet, and is an industry that spends huge amounts on marketing their products. As previously mentioned, individuals with lower incomes are more likely to have children with caries, which is exacerbated by high sugar-containing meals being cheaper and more readily accessible.[59] There is a desperate need for developing strategies that counteract the influence of industry on health.[68] Dr Nigel Carter, Chief Executive of the Oral Health Foundation, UK states:

"How do you convince people living in low socioeconomic groups, who struggle to afford dental care and are more likely to have poor diets, to value oral health and eat and drink healthier when overall health is not valued?"

The dental profession along with policy makers need to apply greater pressure on the corporations that have the most influence and power in sustaining oral health inequalities, such as the sugar and tobacco industries. It should no longer be acceptable that corporations whose products and actions clearly have negative impact on population oral health have a seat at the health policy table. Vulnerable communities who are already at risk of poorer health, are targeted by corporate activities from large sugar, alcohol and tobacco companies, and this needs to be managed appropriately with public health campaigns.[71] In addition to advice on tooth-brushing, this should be coupled with self-care advice on healthy eating which largely revolves around reducing the consumption of free sugars found in soft drinks, honey and syrups, not those found naturally in fruits and milk products.

Chapter 3: The cost effectiveness of good oral health

The mouth has been described as "a marker of people's social position and future disease risk".[72] Despite this, a 'treat over prevent' model, is the go-to strategy in oral care which has failed to remedy the global challenge of oral diseases. Although largely preventable, oral diseases suffer from inadequate funding for prevention and treatment, especially in low- and middle-income countries where the treatment costs often exceed available resources. In many countries, care-delivery models and financing for oral health are often more restricted than for medical care.[21] In a UK survey conducted by the National Association of Citizens Advice Bureaux, 43% of patients stated that they had avoided a dental check-up in the preceding 12 months as they could not afford it.[73]

As a result, unmet needs in dentistry are reported more often than unmet needs in medical care, the main reason being the expense of dental treatment. Because of the link between oral diseases and socio-economic status, the costs of treating oral diseases are large, and often unaffordable for families, not just in low- and middle-income countries, but in high income countries too. A 2015 comparison of healthcare expenditures in 28 EU member states found dental diseases to be the third most costly disease (€90 billion per year) behind diabetes (€119 billion per year) and cardiovascular diseases (€111 billion per year).[21]

Direct, indirect and intangible costs of periodontitis

The economic impact of unmanaged oral health can be broken down into three main costs: direct costs (often related to treatment expenditures), indirect costs (losses due to absence from work), and intangible costs (pain, difficulties with speech, low self-confidence, problems with expressing emotions such as smiling, etc).[21]

Direct treatment costs due to dental diseases worldwide were estimated at US$298 billion yearly, corresponding to an average of 4.6% of global health expenditure. More specifically, on average, oral healthcare represented 30% of health expenditure across European OECD countries in 2020.[17] Household spending on dental care and long-term health care can also be high, averaging 13% of healthcare costs in 2020.[17]

In parallel, indirect costs due to dental diseases worldwide amounted to US$144 billion yearly, corresponding to economic losses within the range of the 10 most costly global diseases.[74] For example, post-operative discomfort and pain experienced by some patients who have to undergo surgery can affect them physically, psychologically and socially. This can result in them taking time off work which has been associated with a collective lost productivity cost of around 54 billion USD per year.[1] A national study conducted in Canada found that dental-related issues resulted in an average of 3.5 hours of lost working time per person per year,[75] adding to a national 40 million lost work hours.

The intangible cost of poor oral health on people's self-confidence and quality of life should also not be overlooked.[76,77] Some of the more severe side effects of periodontitis include gum bleeding, halitosis, receding gums and tooth loss,

which is linked to impairments with chewing, increased anxiety, and feelings of shame and vulnerability.[5] Better managed oral health and better self-confidence could lead to better management of other conditions.

Cost-effectiveness of preventing periodontitis

Cost-effectiveness analyses are a way to examine both the costs and health outcomes of one or more disease interventions. They also capture the scale of a problem in tangible, quantitative terms, illuminating the aggregate burden of illness on society and the value of evidence-driven intervention.

Some studies have looked into the cost-effectiveness of dental interventions implemented at an early age to improve oral health and prevent periodontitis in later life.[78,79] For example, a recent study that assessed the effectiveness of supervised brushing, water fluoridation and provision of toothbrushes and toothpaste to 0-to-5-year-olds in a Scottish nursery, resulted in savings of around £3 million over a one-year period.[78] A further study evaluated the projected effectiveness of the Mouth Care Matters programme implemented in Surrey, Kent and Sussex between 2015 and 2020. It aimed to improve healthcare staff's awareness of the link between mouth care and general health while providing enhanced oral health skills and support through treatment to patients. This study projected that for every £1 invested in the programme, £2.66 of cash-releasing and non-cash releasing benefits (e.g., time per patient, prescription costs, bed-days) will be made available to the healthcare system, and a further £17 in social benefits are projected. Additionally, 3,878 quality-adjusted life years (QALYs) are projected, and £106,011 prescription costs could be avoided along with 20,435 bed-days saved.[79]

Early education is also necessary in adulthood to prevent periodontitis. Unlike dental caries where the childhood interventions discussed above are timelier, prevention of periodontitis is also likely to be cost-effective as it can reduce dental costs in later life. A recent study assessing the long-term costs of treating chronic periodontitis in Germany highlighted that regular attendance and having more severe periodontitis came with higher costs per year, but costs were lower for less severe patients.[80] Further, recent studies have shown that early detection and education in primary schools is extremely cost-effective and has produced successful outcomes as well as efficiently raising awareness of dental care.[59,62,64]

Modelling approach

Cost-effectiveness studies specifically covering the periodontal pathway of care have largely been overlooked, with those that exist limited to case studies which focus on specific national and local initiatives. This makes it difficult to generalise the results to a wider population.

Because of the paucity of studies attempting to model the economic burden and return-on-investment (ROI) for periodontitis, especially across countries, the EIU developed a model to assess periodontitis costs and health outcomes in six European countries (France, Germany, Italy, the Netherlands, Spain and the UK). The primary objective of the modelling is to determine the ROI of periodontitis treatment but also the management of gingivitis, recognising that the prevention and management of gingivitis is essential to the prevention of periodontitis.

Methods

Impact of treatment

To measure the impact of treatment, the model uses the EFP treatment guidelines which consist of four steps (Figure 2). Figure 2 provides a diagram of the steps involved in the progression from health to having gingivitis and periodontitis, as well as the intervention points. The national cohorts of individuals, and the probability of transitioning between the disease and treatment states outlined in Figure 2, were modelled separately for each country. Individuals begin the model either in the healthy compartment or the compartments representing periodontal disease and treatment, depending on the local epidemiological situation. Individuals who are diagnosed and access dental care move through the different stages of the periodontitis treatment states from stage one treatment to stage four. At all intervention stages, diagnosed individuals can move to an unmanaged state, representing individuals who choose not to or cannot afford to access treatment. Individuals experience adverse outcomes associated with periodontitis in each disease state, which negatively affect quality of life, and can be partially reversed by the four stages of treatment. Individuals cannot return to a healthy state after they have developed periodontitis. The probabilities and overall proportion of people that transition between the disease and treatment states are outlined in Appendix 1 (Tables A1 and A2).

The monetary value of improved periodontal care was determined using a willingness-to-pay approach, with each healthy life year gained monetised as 2.5 times the national Gross Domestic Product per capita. This relatively conservative factor was chosen with consideration of the diverse literature on the topic,[81,82] and is likely to yield more conservative estimates than alternatives such as Value of Statistical Life.[83]

Prevalence data

The population size and age structure by country were determined from the World Population Prospects using five year age groups. The stage two periodontitis population was modelled in this study, defined as moderate disease. It is estimated that 80% of all people with periodontitis are in this category (expert opinion), whereas 10% are expected to be at stage one (mild periodontitis) and 10% are at stage three to four (severe periodontitis). Table 2 presents the prevalence data for people in stage two that was used in the model by age band. We assumed that no one under the age of 35 will be diagnosed with periodontitis.

Table 2: Epidemiology of periodontitis

Prevalence data	35-64 point estimate	65+ point estimate	35-64 population	65+ population
France	11.4%	18.2%	25,255,800	11,952,667
Germany	16.7%	57.8%	35,304,533	16,208,000
UK	10.7%	47.2%	26,496,467	11,667,666
Spain	6.2%	29.2%	21,367,067	8,119,600
Netherlands	16.8%	31.6%	6,888,000	3,278,533
Italy	17.0%	26.4%	32,636,533	16,208,000

Impact of managed oral health on quality of life

To estimate the impact of periodontitis management and prevention on quality of life, the model also estimates healthy life years (HLYs) for each scenario. The costs associated with each step of treatment were determined using dental tariffs or cost estimates which were provided by dentists in each country. They were incorporated into the model as a mean value per intervention. A discount rate of 3% for future costs and benefits was applied in the final analysis. More information on how prevalence, HLYs and costs were calculated and incorporated into the model are available in Appendix 1.

Modelled scenarios

The ROI analysis presents the overall costs and benefits associated with the treatment of periodontitis, as well as the impact of not treating it, using the following scenarios:

Scenario 1 – Baseline: A 'business as usual' approach, where treatment rates, dental coverage and management of gingivitis and periodontitis for the population are assumed to continue as currently.

Scenario 2 – Reduced gingivitis management: Reduces the rate of gingivitis management from 95% to 10%. Fewer patients with gingivitis are treated and more therefore progress to periodontitis.

Scenario 3 – Elimination of gingivitis: Incident gingivitis is eliminated through improved oral homecare. This scenario represents prevention of periodontitis through prevention of gingivitis.

Scenario 4 – Unmanaged periodontitis: A 'doing nothing' scenario in which no periodontitis is managed.

Scenario 5 – Managed periodontitis: 90% of periodontitis is diagnosed, and all those diagnosed are managed.

Each scenario is modelled over a time-horizon of 10 years with four-month cycles in order to capture the costs associated with periodontitis and downstream complications, in addition to the avoided costs and gains in benefit resulting from improved oral health. For each country the model calculates the impact of each scenario on the following outcomes:

- Total HLYs gained
- Total costs (in Euros)
- Cost per HLY
- Incremental cost-effectiveness ratio
- Return on investment

Model Results

Scenario 1: Baseline

Across all six countries, the baseline scenario retains the 'business as usual' approach reflecting current treatment rates and dental coverage, as well as current management of gingivitis and periodontitis. The baseline scenario is most costly in Italy at 96.8Bn Euros, and least costly in the Netherlands at 18.7Bn. The cost per HLY is the highest in Italy at 183 Euros and the lowest in Germany at 35 Euros. The total HLYs for the baseline scenario range from 632m in Germany to 132m in the Netherlands.

Scenario 2: 10% gingivitis management

If we consider a reduction in the rate of gingivitis management from 95% to 10%, the total HLYs are reduced and costs rise in all countries except Germany, where costs slightly reduce by 491m Euros (Table A1). In all other countries, an incremental increase in costs can be seen of between 22Bn Euros in Italy and 1.3Bn Euros in France, and a decrease in 5.1m HLYs in Italy and 1.1m HLYs in the Netherlands. Reduced management of gingivitis reduces the average cost-effectiveness to between 227 Euros per HLY in Italy, to 42 Euros per HLY in France. Across all countries this scenario has a negative ROI (Table A2).

Scenario 3: Elimination of gingivitis

If we consider an elimination of incident gingivitis (e.g., through improved oral homecare), the total HLYs rise in all countries but most substantially in Germany, at an incremental increase of 5.7m HLY compared to baseline. Scenario 3 predicts the highest total HLYs in all countries apart from the Netherlands where scenario 5 has the highest (Figure 4). Costs also reduce in all countries compared to baseline, from 36Bn Euros in Italy to 7.8Bn Euros in the Netherlands (Table A1, Figure 5). The average cost-effectiveness improves in all countries in this scenario compared to the previous one, from 18 Euros per HLY in France to 114 Euros per HLY in Italy. This scenario has a strong ROI in all countries (Table A2), meaning that net benefit (benefits minus intervention costs) is positive.

Scenario 4: No Periodontitis management

If we consider a scenario where periodontitis is never managed, we observe a reduction of HLY in all countries, from 2.2m in Germany to 0.36m in the Netherlands (Table A1). This scenario has the second lowest total HLYs in all countries, with scenario 2 (reduced gingivitis management) having the lowest. In this particular scenario, costs account only for the management of gingivitis. This scenario has a negative ROI for all countries, meaning that net benefit is negative (Table A2).

Scenario 5: 90% Periodontitis diagnosed and managed

Finally, if we assume a 90% periodontitis diagnosis rate and treatment of all diagnosed periodontitis, we observed an incremental increase of HLYs compared to baseline in all countries, from 7m in the Netherlands to 1.8m in Spain. There is also an incremental increase in costs for all countries, from 290Bn in Italy to 60Bn in Spain (Table A1, Figure 5). Despite these cost increases, there is a positive ROI in all countries (Table A2). Figure 3 visually represents scenario 5 as having the highest total costs in all countries, but Figure 4 shows scenario 5 achieves the second highest HLYs across all countries except in the Netherlands, where it achieves the highest total HLYs (Figure 4).

A one-way deterministic sensitivity analysis was also undertaken which did not reveal any parameters with substantial impact on model results. For further results by country see appendix I. For the UK, two analyses were conducted using out-of-pocket (OOP) costs and NHS costs. In figures 3-5 the results from the UK using OOP costs are presented as they are the most comparable to other countries. The NHS costs appear a lot cheaper (Table A1) but this is because they do not fully cover all periodontitis treatment. For the exhaustive results overall see appendix II-III.

The "best buy" scenario

Scenario 3 is the most beneficial scenario when considering all the outcomes measured together. It costs less than the business as usual scenario in all countries, it has a very strong return on investment and generates the most HLYs in all countries except the Netherlands where it produces the second highest HLYs. This result highlights how integral individual level prevention through home care is to good oral health, in terms of being cost effective to society and preventing progression to the more difficult and costly to treat, periodontitis. Although not measured in the model, preventing the progression of gingivitis to periodontitis, could save many more costs associated with other health conditions that share risk factors with periodontitis such as diabetes and heart conditions. Dental services which deliver preventative advice relating to gingivitis are (in some European countries) provided by the dental support team such as dental nurses and hygienists (not necessarily a qualified dentist). Encouraging a rational distribution of tasks to the dental support team could also promote cost effectiveness and save qualified dentist's time for more severe complications. This 'task shifting' approach is adopted in many countries where the intention is to optimise the potential of the existing workforce.[84]

Figure 3: Total cost of each scenario by country (billions)

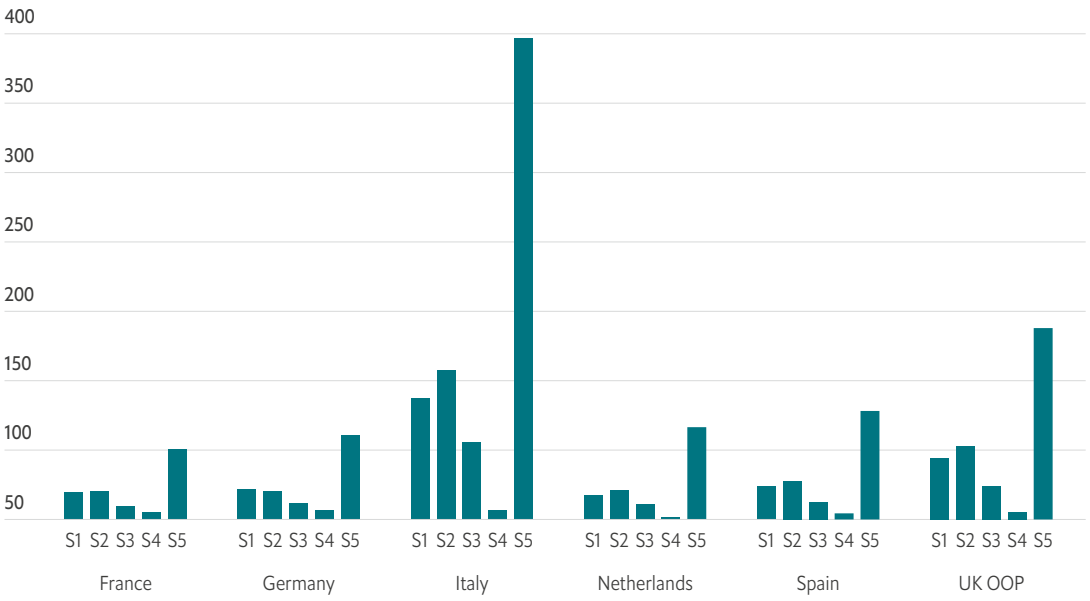


Figure 4: Total healthy life years by scenario (millions)

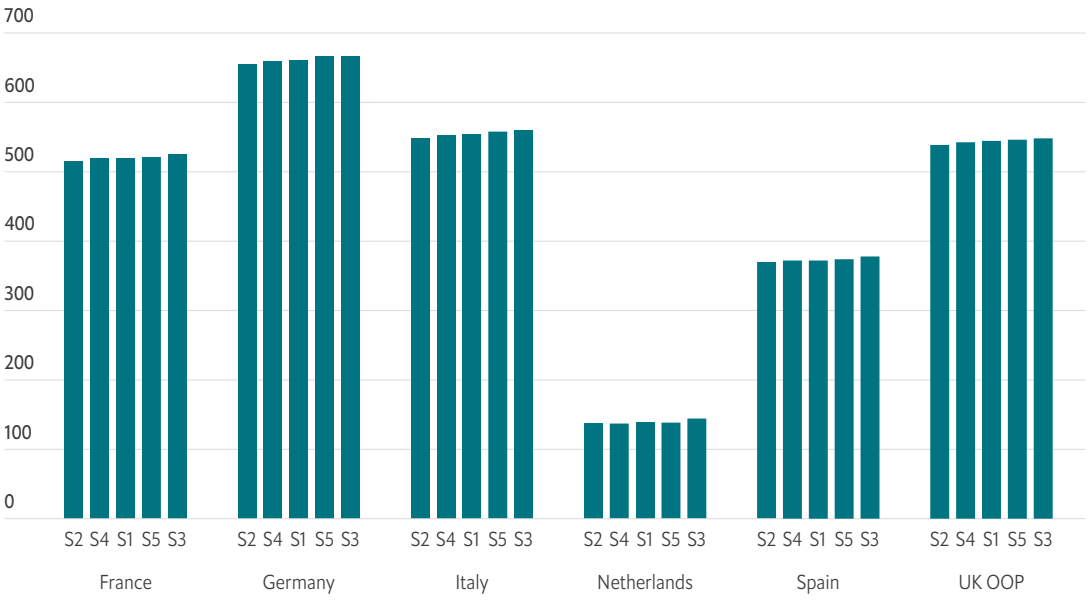
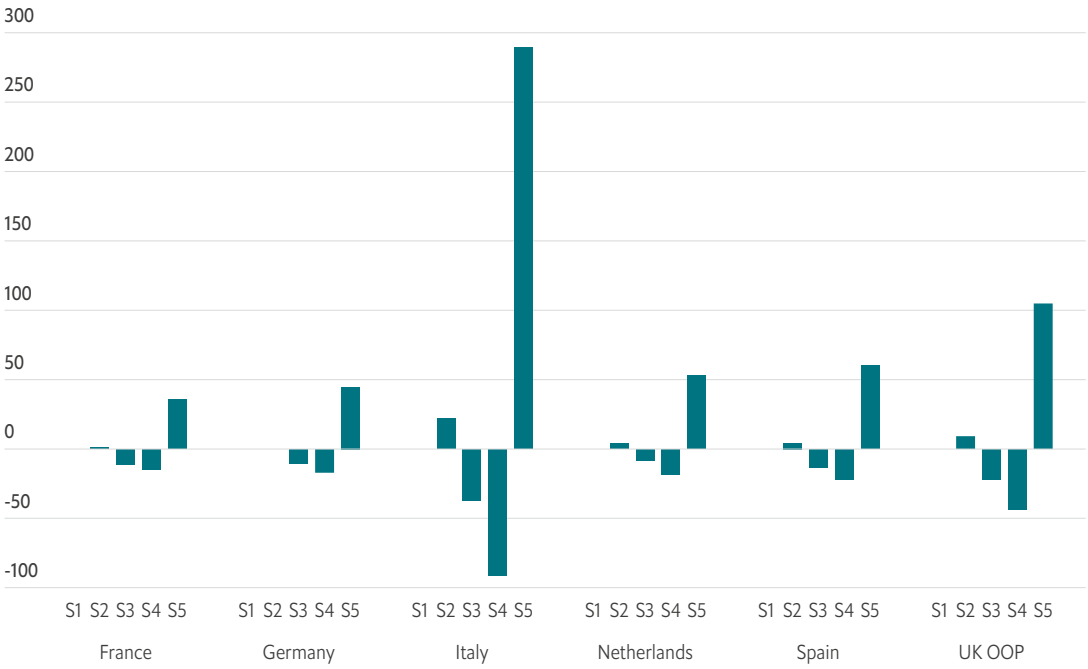


Figure 5: Incremental costs by scenario compared to baseline (billions)



Conclusion

This report has explored the economic, societal and individual approaches to tackling oral health in Europe. Considering the findings of this report together, we arrive at five key recommendations:

1. Our cost analysis has helped demonstrate the economic benefit for increased prevention, diagnosis and management of periodontitis. The role of home care by patients is of paramount importance to prevent gingivitis and periodontitis. Our economic analysis shows that both eliminating gingivitis (the precursor to periodontitis) using home care prevention techniques (such as tooth brushing and interdental brushing) and increasing the diagnosis rate of periodontitis to 90% with all patients diagnosed being managed, have a positive return on investment in all the European countries in this study. Although not directly measured in our analysis, oral health prevention can be provided by members of the broader oral healthcare team rather than a qualified dentist. This could further promote the cost effectiveness of gingivitis prevention. Despite there being an initial increase in costs for scaling up periodontitis diagnosis and management, HLYs increase with this investment compared to 'business as usual'. We have also shown that neglecting to manage gingivitis, can significantly increase costs and reduce HLYs, therefore an emphasis on self-care and prevention is critical from both an individual and a societal perspective.

2. The prevalence of periodontitis has remained largely unchanged over the last 10 years (according to publicly-available data) despite differences in access to treatment across countries. This could be in part due to poor data collection, as it is recognised across the dental literature that epidemiological data on periodontal diseases is very heterogeneous and absent from some European countries. The evidence that exists points to the urgent need for heightened awareness of the burden of periodontitis, to both improve prevention policies and improve access to care.

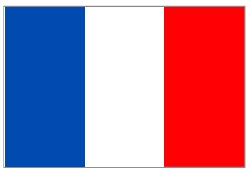
3. While there is a growing body of evidence that supports links between oral health and general health, the value of integrating these systems in practice is still developing. Being able to share information electronically across disciplines may both improve patient care due to the common risk factors shared between some dental and physical health conditions such as diabetes, and contribute significantly to dental/general health research. Integration in practice will also create opportunities for dentists to be more involved in community-based practice and for there to be shared responsibility across healthcare professionals to address unmet oral health needs in vulnerable and marginalised communities.

4. Societal approaches to good oral health are just as important as individual ones. One without the other would exacerbate oral health inequalities which we see both within and across countries. Societal level prevention is of crucial concern to the prevention of periodontitis, especially as it is a disease prevalent in deprived areas. Interventions to promote better periodontal health need to be embedded into relevant and targeted community settings. For example, nursery-based dental care, encouraging health visitors to pass on dental advice and tooth-brushing workshops in schools have all contributed to reducing dental caries in young children.

5. Dental tariffs and the costs of accessing a dentist is a barrier to early treatment for the general public. People are more likely to access the dentist when there is something wrong rather than attend check-ups. Dental tariffs vary widely across Europe, and in the six study countries covered in this report, some such as the UK and France partially cover dental fees while others such as Italy and Spain largely rely on private insurance. The expense of dentistry is a common theme which makes many people avoid check-ups and being handed a prognosis of costly treatments. Armed with information on the cost-effectiveness of managing gingivitis and periodontitis from the analysis presented in this study, dental costs deserve a review from policy makers and commissioners Europe-wide.

Appendix I: Country profiles

France



Prevalence (Per 100 population)[10]	6.9 (5.7-8.3)
Incidence (Per 100,000 person years)[10]	630 (328-1076)
Model of oral healthcare provision	Partially covered

Access to oral health services

In France, comprehensive healthcare is available to all by law, all citizens have an equal and constitutional right to receive healthcare, and every individual is automatically affiliated to a public insurance scheme (Assurance Maladie) according to their economic status. This obligatory insurance gives them the right to be totally or partially reimbursed for their health expenses for themselves and their dependants.[85]

Most oral healthcare is covered. Children and teenagers aged 6, 9, 12, 15 and 18 can benefit from a prevention examination covered 100% by health insurance (mandatory at 6 and 12).

Consultations with dentists are covered by this public health Insurance. Dental care, prostheses and orthodontic treatments are reimbursed at 70% fee-per-item basis for all standard treatments such as extractions, conservative dentistry and prostheses, as well as scaling and sealing.[86] About 5% of the population belonging to either low-income groups or to groups without any income, benefit from free care. Most prosthodontic treatment is paid for entirely by patients. In 2013, approximately 90% of people used complementary insurance schemes to cover all or part of their treatments.[85] About two-thirds of the population visits a dentist at least once a year.[85]

Cost effectiveness and ROI

	Scenario total costs		Incremental against baseline	Incremental against baseline	ROI
	Costs	Cost per HLY	HLY	Costs	
Baseline	19,408,406,030	39	-		
10% gingivitis management	20,674,795,021	42	- 4,320,544	1,266,388,992	-295.4
Elimination of gingivitis	9,071,677,622	18	4,723,464	- 10,336,728,408	40.4
No periodontitis management	5,026,553,728	10	- 1,204,908	- 14,381,852,302	-6.2
90% perio diagnosis rate and all diagnosed managed	55,368,752,569	111	2,377,814	35,960,346,539	4.7

Germany

Prevalence (Per 100 population)[10]	11.2 (9.6-12.9)
Incidence (Per 100,000 person years)[10]	628 (333-1103)
Model of oral healthcare provision	Partially covered

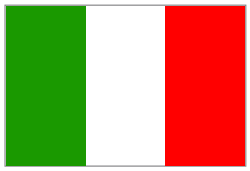
Access to oral health services

In Germany, there is a long-established insurance-based healthcare system of 'sick funds', which are not-for-profit organisations. Almost 90% of the population belong to one of these funds, which provide a legally-prescribed standard package of healthcare covering all medically-necessary conservative and surgical dental treatment as well as necessary orthodontist care for persons aged less than 18.[85] There is also wide use of private insurance. In 2013, there were 43 private health insurance funds plus a rising number of insurance companies offering supplementary health insurance.[85] The actual provision of health care in the statutory system is managed jointly by the sick funds, and the doctors' and dentists' organisations. As with many other aspects of German legislation, responsibilities are split between the federal level and the regional level of the Länder. Dental fees, both inside and outside sick funds and insurance-based care, are regulated.[85]

Cost effectiveness and ROI

	Scenario total costs		Incremental against baseline	Incremental against baseline	ROI
	Costs	Cost per HLY	HLY	Costs	
Baseline	21,872,695,291	35	-	-	
10% gingivitis management	21,380,901,497	34	- 5,008,618	- 491,793,794	- 1007
Elimination of gingivitis	11,834,898,294	19	5,733,917	- 10,037,796,997	57.5
No periodontitis management	5,841,001,719	9	- 2,183,914	- 16,031,693,572	- 12.5
90% perio diagnosis rate and all diagnosed managed	66,387,046,801	104	5,149,556	44,514,351,510	10.4

Italy



Prevalence (Per 100 population)[10]	13.1 (11.2-15.3)
Incidence (Per 100,000 person years)[10]	632 (329-1074)
Model of oral healthcare provision	Not covered

Access to oral health services

In Italy, healthcare is currently a constitutional right for all citizens. In principle, there is a comprehensive oral health care system, which functions within the National Health Service (SSN).[85] The service provided varies enormously, even from town to town within a region. In many areas, only emergency treatment is provided. So, in practice, dental care provided by NHS dentists comprises restorative treatment and only occasionally prosthetics and implants, with co-payment by the patient. Dentistry should be considered as private sector treatment in Italy as only 4% of dental care is provided within the NHS.[85] While the prevalence of periodontitis is lower, the Ministry of Health estimates that mild forms of periodontal disease affect about 60% of the population in Italy.[87]

Cost effectiveness and ROI

	Scenario total costs		Incremental against baseline	Incremental against baseline	ROI
	Costs	Cost per HLY	HLY	Costs	
Baseline	96,842,876,209	183	-	-	
10% gingivitis management	118,981,302,369	227	- 5,142,958	22,138,426,160	- 22
Elimination of gingivitis	61,008,873,723	114	5,633,968	-35,834,002,487	15.2
No periodontitis management	5,931,353,012	11	- 1,762,130	- 90,911,523,197	- 0.7
90% perio diagnosis rate and all diagnosed managed	387,028,774,606	725	3,863,023	290,185,898,396	0.2

The Netherlands

Prevalence (Per 100 population)[10]	10.5 (4.6-20.9)
Incidence (Per 100,000 person years)[10]	629 (335-1055)
Model of oral healthcare provision	Partially covered

Access to oral health services

The Netherlands provides a compulsory basic insurance for all Dutch citizens. This basic insurance contains a standard package of necessary, mostly curative health care. This covers preventive and curative care for all citizens under 18 years old, the cost of a full set of dentures, and care for specific groups of patients, for example persons with a physical and/or mental handicap. All other oral health care can be additionally insured or paid for privately. Although dental treatment is mostly provided under the private system, there is a national scale of maximum fees set by a government appointed body, the National Health Care Authority.[85]

Between 1995 and 2018, nearly all professional groups in oral health care have significantly increased, particularly those of dental hygienists and prevention assistants. The percentage of inhabitants visiting oral health care professionals has largely unchanged, but the type of care provided is slowly moving towards more prevention.[88]

Cost effectiveness and ROI

	Scenario total costs		Incremental against baseline	Incremental against baseline	ROI
	Costs	Cost per HLY	HLY	Costs	
Baseline	18,691,360,271	142		-	
10% gingivitis management	23,262,264,801	178	- 1,110,717	4,570,904,529	- 28.1
Elimination of gingivitis	10,933,303,516	82	1,233,783	- 7,758,056,755	18.7
No periodontitis management	1,289,881,170	10	- 362,665	- 17,401,479,101	- 1.3
90% perio diagnosis rate and all diagnosed managed	72,446,410,847	523	6,962,865	53,755,050,575	13.4

Spain

Prevalence (Per 100 population)[10]	4.3 (3.4-5.3)
Incidence (Per 100,000 person years)[10]	633 (337-1115)
Model of oral healthcare provision	Not covered

Access to oral health services

Comprehensive health care is available to all by law. However, almost all oral healthcare in Spain is provided by private practitioners and patients usually pay the total cost.[85] There is a small Public Dental Service which operates in Primary Health Care Units (Ambulatorios) managed by each regional healthcare institution. This only provides emergency care such as extractions or the prescription of antibiotics. There are 17 Regions (Autonomías), and two autonomous cities, governed by elected local politicians. Some of these already have delegated 'health competencies' which largely operate through programmes which complement national laws. To manage these programmes, each region has an established healthcare institution, for example, the Catalan Institute of Health in Catalonia, the Andalusian Health Service in Andalucía, etc.[85]

The last three national epidemiological surveys reveal profound changes in the epidemiology of periodontal diseases in Spain. In particular, there was a significant decrease in prevalence of periodontitis between 1993 and 2000 and prevalence has since been largely stable since 2000.[89] In the past 15 years, the public sector has considerably expanded its portfolio of services, especially amongst its youngest populations, providing free, routine oral check-ups for children between 6-15 years of age. The proportion of oral health resources in Spain has also significantly grown. Since 1997, while the Spanish population grew by 2.5%, the number of dentists has increased by 136%.[85]

Cost effectiveness and ROI

	Scenario total costs		Incremental against baseline	Incremental against baseline	ROI
	Costs	Cost per HLY	HLY	Costs	
Baseline	25,602,153,191	72	-	-	
10% gingivitis management	30,535,103,222	86	- 3,494,986	4,932,950,032	- 45.7
Elimination of gingivitis	12,906,905,872	36	3,787,300	- 12,695,247,319	19.8
No periodontitis management	4,008,863,508	11	- 943,477	- 21,593,289,683	- 1.8
90% perio diagnosis rate and all diagnosed managed	85,970,518,585	240	1,822,436	60,368,365,394	0.9

The United Kingdom

Prevalence (Per 100 population)[10]	6.4 (5.4-7.4)
Incidence (Per 100,000 person years)[10]	625 (331-1052)
Model of oral healthcare provision	Partially covered

Access to oral health services

The UK has a comprehensive National Health Service (NHS), which is largely funded through general taxation and provides healthcare to all. Oral healthcare in the UK is available from the NHS or privately. Dentistry is one of the few NHS services where patients pay a contribution towards the cost of care. UK patients are charged a fee covering 30% of the treatment cost unless they are exempt.

Specific groups may receive NHS dental care from a GDP without any patient charge, for example children under 18 years old, pregnant or nursing mothers, individuals on welfare benefits, and those under 19 years old who are in full-time education. Some NHS treatments, which are often provided by GDPs, are free of charges for all patients, such as domiciliary care for the housebound and repairs to dentures.[90]

Cost effectiveness and ROI
In the UK, the costs incurred by both the NHS and out-of-pocket were modelled separately.

		Scenario total costs		Incremental against baseline	Incremental against baseline	ROI
		Costs	Cost per HLY	HLY	Costs	
UK out of pocket	Baseline	54,629,981,392	91	-	-	0
	10% gingivitis management	66,199,641,092	112	- 4,113,921	11,569,659,700	-37.9
	Elimination of gingivitis	29,954,250,227	50	4,630,302	- 24,675,731,165	20.5
	No periodontitis management	5,533,819,432	9	-1,433,845	- 49,096,161,960	- 2
	90% perio diagnosis rate and all diagnosed managed	175,563,011,892	292	3,128,782	120,933,030,502	1.7
UK NHS	Baseline	9,042,736,283	15	-	-	0
	10% gingivitis management	5,496,439,520	9	- 4,113,921	- 3,546,296,763	- 119.3
	Elimination of gingivitis	3,542,744,433	6	4,630,302	- 5,499,991,852	88.3
	No periodontitis management	5,533,819,432	9	- 1,433,845	- 3,508,916,852	- 41.4
	90% perio diagnosis rate and all diagnosed managed	18,803,424,038	31	3,128,782	9,760,687,754	32.3

Appendix II: Tables and Figures

Table A1: Model results

		Scenario totals	Scenario totals €		Incremental against baseline	Incremental against baseline		ROI
		HLY	Costs	Cost/HLY	HLY	Costs	ICER (EUR/HLY)	
France	Baseline	497,441,329	19,408,406,030	39	-			
	10% gingivitis management	493,120,785	20,674,795,021	42	- 4,320,544	1,266,388,992	- 293	-295.4
	Elimination of gingivitis	502,164,792	9,071,677,622	18	4,723,464	- 10,336,728,408	- 2,188	40.4
	No periodontitis management	496,236,421	5,026,553,728	10	- 1,204,908	- 14,381,852,302	11,936	-6.2
	90% perio diagnosis rate and all diagnosed managed	499,819,142	55,368,752,569	111	2,377,814	35,960,346,539	15,123	4.7
Germany	Baseline	632,317,755	21,872,695,291	35	-	-		
	10% gingivitis management	627,309,137	21,380,901,497	34	- 5,008,618	- 491,793,794	98	- 1007
	Elimination of gingivitis	638,051,672	11,834,898,294	19	5,733,917	- 10,037,796,997	- 1,751	57.5
	No periodontitis management	630,133,841	5,841,001,719	9	- 2,183,914	- 16,031,693,572	7,341	- 12.5
	90% perio diagnosis rate and all diagnosed managed	637,467,311	66,387,046,801	104	5,149,556	44,514,351,510	8,644	10.4
Italy	Baseline	529,758,745	96,842,876,209	183	-	-		
	10% gingivitis management	524,615,787	118,981,302,369	227	- 5,142,958	22,138,426,160	- 4,305	- 22
	Elimination of gingivitis	535,392,714	61,008,873,723	114	5,633,968	- 35,834,002,487	- 6,360	15.2
	No periodontitis management	527,996,615	5,931,353,012	11	- 1,762,130	- 90,911,523,197	51,592	- 0.7
	90% perio diagnosis rate and all diagnosed managed	533,621,768	387,028,774,606	725	3,863,023	290,185,898,396	75,119	0.2
Netherlands	Baseline	131,623,335	18,691,360,271	142		-		
	10% gingivitis management	130,512,618	23,262,264,801	178	- 1,110,717	4,570,904,529	- 4,115	- 28.1
	Elimination of gingivitis	132,857,118	10,933,303,516	82	1,233,783	- 7,758,056,755	- 6,288	18.7
	No periodontitis management	131,260,670	1,289,881,170	10	- 362,665	- 17,401,479,101	47,982	- 1.3
	90% perio diagnosis rate and all diagnosed managed	138,586,200	72,446,410,847	523	6,962,865	53,755,050,575	7,720	13.4

		Scenario totals	Scenario totals €		Incremental against baseline	Incremental against baseline		ROI
		HLY	Costs	Cost/HLY	HLY	Costs	ICER (EUR/HLY)	
Spain	Baseline	356,735,191	25,602,153,191	72	-	-		
	10% gingivitis management	353,240,205	30,535,103,222	86	- 3,494,986	4,932,950,032	- 1,411	- 45.7
	Elimination of gingivitis	360,522,491	12,906,905,872	36	3,787,300	- 12,695,247,319	- 3,352	19.8
	No periodontitis management	355,791,714	4,008,863,508	11	- 943,477	- 21,593,289,683	22,887	- 1.8
	90% perio diagnosis rate and all diagnosed managed	358,557,627	85,970,518,585	240	1,822,436	60,368,365,394	33,125	0.9
UK (Out of Pocket)	Baseline	520,165,005	54,629,981,392	91	-	-	-	0
	10% gingivitis management	516,051,084	66,199,641,092	112	4,113,921	11,569,659,700	- 2,812	- 37.9
	Elimination of gingivitis	524,795,307	29,954,250,227	50	- 4,630,302	- 24,675,731,165	- 5,329	20.5
	No periodontitis management	518,731,160	5,533,819,432	9	- 1,433,845	- 49,096,161,960	34,241	- 2
	90% perio diagnosis rate and all diagnosed managed	523,293,787	175,563,011,892	292	3,128,782	120,933,030,502	38,652	1.7
UK (NHS)	Baseline	520,165,005	9,042,736,283	15	-	-	-	0
	10% gingivitis management	516,051,084	5,496,439,520	9	- 4,113,921	- 3,546,296,763	863	- 119.3
	Elimination of gingivitis	524,795,307	3,542,744,433	6	4,630,302	- 5,499,991,852	- 1,188	88.3
	No periodontitis management	518,731,160	5,533,819,432	9	- 1,433,845	- 3,508,916,852	2,447	- 41.4
	90% perio diagnosis rate and all diagnosed managed	523,293,787	18,803,424,038	31	3,128,782	9,760,687,754	3,120	32.3

Table A2: Return on Investment analysis

		Scenario totals €		Return on investment		
		Monetised HLY	Costs	Monetised HLYs	Costs	ROI
France	Baseline	42,924,322,445,346	19,408,406,030	-	-	
	10% gingivitis management	42,551,501,744,583	20,674,795,021	- 372,820,700,763	1,266,388,992	- 295
	Elimination of gingivitis	43,331,911,172,603	9,071,677,622	407,588,727,258	- 10,336,728,408	40
	No periodontitis management	42,820,350,675,293	5,026,553,728	- 103,971,770,052	- 14,381,852,302	- 6
	90% perio diagnosis rate and all diagnosed managed	43,129,504,527,511	55,368,752,569	205,182,082,165	35,960,346,539	5
Germany	Baseline	62,581,774,059,196	21,872,695,291	-	-	
	10% gingivitis management	62,086,060,968,034	21,380,901,497	- 495,713,091,162	- 491,793,794	- 1,007
	Elimination of gingivitis	63,149,271,513,596	11,834,898,294	567,497,454,400	- 10,037,796,997	58
	No periodontitis management	62,365,627,669,426	5,841,001,719	- 216,146,389,769	- 16,031,693,572	- 13
	90% perio diagnosis, 100% diagnosed managed	63,091,436,124,762	66,387,046,801	509,662,065,566	44,514,351,510	10
Italy	Baseline	47,785,824,698,224	96,842,876,209	-	-	
	10% gingivitis management	47,321,914,492,065	118,981,302,369	- 463,910,206,159	22,138,426,160	- 22
	Elimination of gingivitis	48,294,025,500,964	61,008,873,723	508,200,802,740	- 35,834,002,487	15
	No periodontitis management	47,626,875,273,149	5,931,353,012	- 158,949,425,075	- 90,911,523,197	- 1
	90% perio diagnosis rate and all diagnosed managed	48,134,280,904,454	387,028,774,606	348,456,206,230	290,185,898,396	0
Netherlands	Baseline	14,677,972,494,726	18,691,360,271	-	-	
	10% gingivitis management	14,554,110,962,882	23,262,264,801	- 123,861,531,844	4,570,904,529	- 28
	Elimination of gingivitis	14,815,557,741,731	10,933,303,516	137,585,247,005	- 7,758,056,755	19
	No periodontitis management	14,637,529,892,665	1,289,881,170	- 40,442,602,061	- 17,401,479,101	- 1
	90% perio diagnosis rate and all diagnosed managed	15,454,436,234,890	72,446,410,847	776,463,740,164	53,755,050,575	13
Spain	Baseline	22,501,692,691,515	25,602,153,191	-	-	
	10% gingivitis management	22,281,240,367,255	30,535,103,222	- 220,452,324,260	4,932,950,032	- 46
	Elimination of gingivitis	22,740,583,217,492	12,906,905,872	238,890,525,977	- 12,695,247,319	20
	No periodontitis management	22,442,181,258,740	4,008,863,508	- 59,511,432,775	- 21,593,289,683	- 2
	90% perio diagnosis rate and all diagnosed managed	22,616,646,030,474	85,970,518,585	114,953,338,959	60,368,365,394	1

		Scenario totals €		Return on investment		
		Monetised HLY	Costs	Monetised HLYs	Costs	ROI
UK (Out of pocket)	Baseline	53,958,506,717,764	54,629,981,392		-	-
	10% gingivitis management	53,531,755,504,549	66,199,641,092	- 426,751,213,216	11,569,659,700	- 44
	Elimination of gingivitis	54,438,823,859,143	29,954,250,227	480,317,141,379	- 24,675,731,165	24
	No periodontitis management	53,809,769,037,101	5,533,819,432	- 148,737,680,663	- 49,096,161,960	- 2
	90% perio diagnosis rate and all diagnosed managed	54,283,066,007,793	175,563,011,892	324,559,290,029	120,933,030,502	2
UK (NHS)	Baseline	53,958,506,717,764	9,042,736,283		-	-
	10% gingivitis management	53,531,755,504,549	5,496,439,520	- 426,751,213,216	-	- 137
	Elimination of gingivitis	54,438,823,859,143	3,542,744,433	480,317,141,379	- 5,499,991,852	102
	No periodontitis management	53,809,769,037,101	5,533,819,432	- 148,737,680,663	- 3,508,916,852	- 48
	90% perio diagnosis rate and all diagnosed managed	54,283,066,007,793	18,803,424,038	324,559,290,029	9,760,687,754	37

Appendix III: Modelling methods

Model description

Individuals are included in the model according to national level periodontitis and overall gingivitis prevalence data. Although the primary objective of this modelling work is to determine the return on investment of periodontitis treatment, the model also includes the diagnosis and management of gingivitis, in recognition that the prevention and management of gingivitis is essential to the prevention of periodontitis.

The model structure allows individuals to transition from healthy to gingivitis; gingivitis to healthy or undiagnosed periodontitis; undiagnosed periodontitis (which is unmanaged) to diagnosed periodontitis; diagnosed periodontitis to unmanaged or step one; step one to step two, step four management or unmanaged; step two to step three, step two to step four management or unmanaged; step three to step four management or unmanaged. Individuals can also return from step four management to step three or become unmanaged. Individuals cannot return to a healthy state after they have developed periodontitis.

We modelled the national population cohorts in 4-month cycles (3 cycles per year). For each cycle, we modelled transitions between disease and treatment states according to the probabilities shown in Table A3 (best estimates regarding disease transitions), and the overall transition matrix shown in Table A4. It should be noted that approximately 50% of people that require treatment do not access dental care (expert opinion). To account for half of the population not accessing routine care, we modelled a 50% reduction in the rate of gingivitis management, reflecting the proportion of individuals with gingivitis not seeking care.

Background mortality by age group was derived from the WHO Global Health Observatory indicator LIFE_0000000030, representing the probability of dying between ages x and x+n.[91] The most recent year available was used. Five-year mortality rates for the five year age buckets reported by the GHO were rescaled to four-month mortality rates.

Sensitivity analysis

To account for uncertainty, we will employ a univariate deterministic sensitivity analysis (DSA). DSA assesses the parameter uncertainty across treatment effect estimates, disease transition probabilities, associated costs and utility values. Uncertainty will be measured using the lower and upper bounds of 95% confidence intervals as recommended by the International Society of Pharmacoeconomics and Outcomes Research and Society for Medical Decision Making Modeling Good Research Practices Task Force.[92] Where 95% confidence internals are unavailable, plausible ranges and observed ranges will be used.

Data inputs

Population data:
The model population size and age structure were determined by country from the World Population Prospects (WPP), using the breakdown by five year age groups.

Prevalence data:
The prevalence of stage two periodontitis in the age group 35-64 was calculated by dividing the prevalent cases of severe periodontitis by the total population aged 35-64. This was then multiplied by the proportion of people estimated to have moderate periodontitis (80%).

Stage two prevalence data for people aged 65+ was calculated by multiplying the 65+ population by the prevalence of severe periodontitis (stage three to four). Stage three to four periodontitis and stage one (mild) periodontitis are both estimated to account for 10% of overall periodontitis. Therefore, we calculated the number of people with stage two periodontitis as the total population with periodontitis, minus the sum of people with stage one, three, four periodontitis, divided by the 65+ total population.

We assumed that zero cases of periodontitis would be identified in those aged 34 years and under. We also assumed that people aged 34 and under had zero prevalence of gingivitis. Although a simplifying assumption, the low rate of progression from gingivitis to periodontitis in this age group means the impact on model results are minimal.

Table A3 provides the probabilities of transitioning through model states. All probabilities are for stage two (moderate) periodontitis. Once treatment is initiated, we assume a reduced probability of becoming unmanaged (10%) relative to individuals who have just been diagnosed but not yet initiated treatment (30%). The transitions between steps of treatment are scaled according to this risk. i.e., once 10% of individuals have transitioned to unmanaged, the probabilities of moving between steps of treatment outlined in Table A4 are applied to the remaining population.

Table A2: Return on Investment analysis

Transition probability	Value	Source
Risk per cycle of progressing from gingivitis to periodontitis	5.0%	Expert opinion
Probability per cycle of being treated if having gingivitis	95.0%	Expert opinion
Gingivitis treatment success	50.0%	Expert opinion
Proportion of prevalent currently undiagnosed periodontitis that is diagnosed each cycle	30.0%	Expert opinion
Proportion newly diagnosed with unsavable teeth	0.0%	
Probability per cycle of staying in step 1	25.6%	Expert opinion
Probability per cycle of progressing from step 1 to step 2	61.7%	Expert opinion
Probability per cycle of progressing from step 1 to step 4	12.8%	Expert opinion
Probability per cycle of progressing from step 2 to step 3	19.0%	Expert opinion
Probability per cycle of progressing from step 2 to step 4	81.0%	Expert opinion
Probability per cycle of staying in step 3	21.7%	Calculated from expert opinion
Probability per cycle of progressing from step 3 to step 4	78.3%	Expert opinion
Probability per cycle of staying in step 4	85.8%	Calculated from expert opinion
Probability per cycle of progressing from step 4 to step 3	14.2%	Expert opinion
Probability of having unmanaged periodontitis	30.0%	Expert opinion
Probability of having unmanaged periodontitis, given treatment initiated	10.0%	Expert opinion

Table A4: Transition probabilities

	Healthy**	Gingivitis^	Gingivitis managed	Undiagnosed periodontitis	Periodontitis	Extract un-saveable teeth***	Step 1	Step 2	Step 3	Step 4	Unmanaged	Dead*	Row sum:
Healthy	62.0%	38.0%										(1)	1.0000
Gingivitis		0.0%	95.0%	3.5%	1.5%							(1)	1.0000
Gingivitis managed	50.0%	50.0%										(1)	1.0000
Undiagnosed periodontitis				70.0%	30.0%							(1)	1.0000
Periodontitis						0.0%	70.0%				30.0%	(1)	1.0000
Extract unsavable teeth												(1)	1.0000
Step 1							23.0%	55.5%		11.5%	10.0%	(1)	1.0000
Step 2									17.1%	72.9%	10.0%	(1)	1.0000
Step 3									19.5%	70.5%	10.0%	(1)	1.0000
Step 4									12.8%	77.3%	10.0%	(1)	1.0000
Unmanaged											100.0%	(1)	1.0000

Notes: *National level background mortality by age ** Probabilities modulated by national level epidemiological data, e.g., 100% healthy-healthy transition is modified by national incidence of background mortality M (data not shown) *** Extracting un-saveable teeth was dropped from the model after clinical feedback, however this is shown for completeness. ^ The incidence of gingivitis was calculated from the estimated prevalence of 80%, to ensure a steady state: 95% of individuals with gingivitis move to managed gingivitis, after which 50% return to gingivitis (treatment failure). So for every cycle, 95%*50% = 47.5% of individuals with gingivitis (prevalent pool) need to be replaced, we multiply this on the prevalence of 80% to arrive at 38% of healthy individuals transitioning to gingivitis.

We make the following further assumptions on initial state distribution in the first cycle of the model, on the reduction in adverse outcomes according to treatment steps, and on basic epidemiology (Table A5).

Table A5: Assumptions on state distributions, prevalence of adverse outcomes of periodontitis and epidemiology

Assumptions for initial state distribution of prevalent periodontitis cases	Baseline values	Minimum	Maximum
Initial distribution for step 1 in first model cycle	10%		
Initial distribution for step 2 in first model cycle	10%		
Initial distribution for step 3 in first model cycle	10%		
Initial distribution for step 4 in first model cycle	20%		
Unmanaged periodontitis prevalence	40%		
Undiagnosed periodontitis prevalence	10%		
Epidemiological assumptions			
Zero prevalence gingivitis and periodontitis in less than age	35	25	45
Higher prevalence age group, above years of age	65		
Prevalence of gingivitis in age 35+	80%	50%	100%
Incidence of gingivitis in age 35+	38%	25%	75%
Reduction of adverse outcomes			
Step 4 reduction in bleeding gums*	90%	10%	100%
Proportion of all periodontitis which is stage 2	80%	50%	100%

Note: * reduction in prevalence of adverse outcomes of periodontitis by step of treatment is assumed to apply to bleeding gums only. E.g., step 1 is assumed associated with a 50% reduction in bleeding gums, while step 4 as associated with a 90% reduction. For other adverse outcomes, the reduction in prevalence of adverse outcomes is guided by data.

Table A6 shows the distribution of adverse outcomes associated with periodontitis by treatment step. The prevalence of abscess in the unmanaged population is derived from the literature, while the prevalence of abscess in treatment steps is derived using interpolation of the assumptions in Table 4. The relative reduction in prevalence of bleeding gums is based on the assumptions in Table 4, other prevalence estimates are based on expert opinion.

Table A6: Prevalence of morbidities by treatment stage

	Unmanaged	Step 1	Step 2	Step 3	Step 4	Sources
Prevalence of abscess	59.70%	51%	42%	34%	25%	Herrera et al. 2017[93]
Prevalence of bleeding gums	100%	43%	30%	17%	4%	Murillo et al (2018)[94]
Prevalence of bone loss	100%	100%	100%	100%	100%	Expert opinion
Prevalence of receding gums	100%	100%	100%	100%	100%	Expert opinion
Prevalence of tooth loss*	0%	0%	0%	0%	0%	Expert opinion

Notes: We assume some adverse outcomes are not reversible: bone loss, receding gums and tooth loss.
* For stage 2 periodontitis, tooth loss is assumed no greater than in the general population

To determine quality of life implications of periodontitis management and prevention, we use disutility data from the Global Burden of Disease study, in combination with expert elicitation for adverse outcomes for which no disutility data is available. Table A7 shows the disutility data used in the model for specific states, as well as periodontitis specific adverse outcomes. Individuals can have different severities of each consequence of periodontitis, which is reflected in the wide ranges of disutility for some conditions. When expert opinion was used to derive disutility data, we applied an average between the high and low disutility associated with each condition.

Table A8 shows the calculated disutilities by model states. Because individuals with severe periodontitis can have a mix of adverse outcomes at any one time, we use the additive approach to combining multimorbid disutility.[93] Briefly, in this approach we define the disutility of each adverse outcome (abscess, bleeding gums, bone loss, receding gums) as the difference between the disutility of periodontitis on its own and the disutility of periodontitis plus the adverse outcome. We then sum across the disutility of periodontitis and all individual complications, according to the prevalence of each complication. We assumed the disutility associated with periodontitis to remain constant over time.

Table A7: Disutility data

Disutilities	Average	Low range	High range
Healthy	-	-	-
Gingivitis*	0.0033	0.0003	0.0100
Periodontitis	0.0070	0.0030	0.0140
Periodontitis with abscess*	0.0400	0.0150	0.1000
Periodontitis with bleeding gums*	0.0443	0.0070	0.0700
Periodontitis with bone loss*	0.0455	0.0070	0.0700
Periodontitis with receding gums*	0.0488	0.0100	0.0700
Periodontitis with any tooth loss	0.0572	0.1000	0.0700
Dead	1.0000	1.0000	1.0000

Note: * disutilities estimated from expert opinion, based on existing anchor points of healthy, periodontitis, periodontitis with any tooth loss and death.

Table A8: Disutility data by treatment step

Disutilities	Base case	Base case	Min	Max
Healthy	-	-	-	-
Gingivitis	0.003	0.003	0.000	0.010
Managed Gingivitis	0.003	0.003	0.000	0.010
Undiagnosed periodontitis	0.044	0.044	0.007	0.070
Periodontitis	0.007	0.007	0.003	0.014
Extract un-saveable teeth	-	-	-	-
Step one treatment	0.120	0.120	0.028	0.221
Step two treatment	0.112	0.112	0.025	0.204
Step three treatment	0.105	0.105	0.023	0.186
Step four management	0.097	0.097	0.021	0.168
Unmanaged	0.144	0.144	0.033	0.270
Dead	1.000	1.000	1.000	1.000

Table A9 summarises the costs associated with steps one to four of periodontitis management. Costs were determined from the healthcare perspective and were incorporated into the model as a mean value per intervention/comparator per cycle.

The tables specify who bears the cost, i.e. from which budget the services are paid (private out-of-pocket, private insurance, public reimbursement).

Table A9: Costs associated with step one to four of periodontitis management and gingivitis management (2021 EUR, 2021 GBP)

	Out of pocket			Private insurance			Public insurance					
Costs step one	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Total cost	Mix	Max
France	50	50	50	7	7	7	16	16	16	73	73	73
Germany	100	50	150				49	49	49	149	99	199
UK (OOP)	380	360	400							380	360	400
UK (NHS)							23.8	0	23.8	24	0	24
Spain	264	150	845							264	150	845
Netherlands	312	192	681							312	192	681
Italy	342	240	600							342	240	600

	Out of pocket			Private insurance			Public insurance					
Costs step two	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Total cost	Mix	Max
France	230	160	300	300	300	600				530	460	900
Germany							215	45	430	215	45	430
UK (OOP)	1450	1050	1850							1450	1050	1850
UK (NHS)							65.2	0	74.2	65.2	0	74.2
Spain	295	150	900							295	150	900
Netherlands	1153	215	1450							1153	215	1450
Italy	360	250	450							360	250	450

	Out of pocket			Private insurance			Public insurance					
Costs step three	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Total cost	Mix	Max
France	450	300	600	300	300	300				750	600	900
Germany							105	105	105	105	105	105
UK (OOP)	1300	1000	1600							1300	1000	1600
UK (NHS)							65.2	0	65.2	65.2	0	65.2
Spain	1383	580	5900							1383	580	5900
Netherlands	3178	708	16638							3178	708	16638
Italy	5132	3600	6800							5132	3600	6800

Costs step four	Out of pocket			Private insurance			Public insurance			Total cost	Mix	Max
	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max			
France	0	0	0	13	13	13	30	30	30	43	43	43
Germany							100	50	150	100	50	150
UK (OOP)	185	160	210							185	160	210
UK (NHS)							23.8	0	23.8	23.8	0	23.8
Spain	159	80	225							159	80	225
Netherlands	289	200	390							289	200	390
Italy	96	60	130							96	60	130

Costs for gingivitis*	Total cost	Min	Max
France	36.5	18.25	73
Germany	36.5	18.25	73
UK	36.5	18.25	73
Spain	36.5	18.25	73
Netherlands	36.5	18.25	73
Italy	36.5	18.25	73

* Costs for gingivitis management were assumed to be 50% of the cost of step 1 treatment in France, to account for a simplified regimen compared with initial periodontitis management

Model limitations

It is important to note the limitations to this study. First, there was a paucity of relevant data in the literature to inform model parameters. The majority of data collected was either specific to particular forms of periodontitis, such as severe, and was not generalisable for the model. In other cases, the prevalence of tooth loss was presented for the general population and not for our population of interest: people with periodontitis. As a result, this study utilised expert opinion for many of the model parameters, and omitted other parameters, such as the extraction of un-saveable teeth.

The model structure itself also contains limitations as it was built to follow clinical interventions steps, rather than specific disease states. This is because people in different disease states can belong to multiple treatment steps, according to the severity of their condition.

It is also important to note that we assumed constant states of disutility. This could overestimate the value of periodontitis treatment if the disutility decreases over time as people with periodontitis become accustomed to their condition. Furthermore, due to a lack of data, the utility of abscess varies considerably, which is related to varying clinical manifestations that can be found.

It is estimated that about 50% of people requiring dental care do not access services (expert opinion). However, due to a lack of data, we were unable to explore whether populations seeking care have biased the results. For example, it is possible that populations that actively seek dental care have a significantly higher standard of oral health. If true, this would systematically underestimate our results as the impact of preventing periodontitis in the wider population would carry significantly higher health benefits.

Appendix IV: References

1. Wong LB, Yap AU, Allen PF. Periodontal disease and quality of life: Umbrella review of systematic reviews. Journal of periodontal research. 2020.
2. Papapanou PN, Sanz M, Buduneli N, Dietrich T, M F, Daniel H. Fine DH, et al. Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. Journal of Clinical Periodontology. 2018;45(Suppl 20):S162-S70.
3. Sanz M, Herrera D, Kebschull M, Chapple I, Jepsen S, Beglundh T, et al. Treatment of stage I–III periodontitis—The EFP S3 level clinical practice guideline. Journal of Clinical Periodontology. 2020;47(S22):4-60.
4. James SL, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018;392(10159):1789-858.
5. Ferreira MC, Dias-Pereira AC, Branco-de-Almeida LS, Martins CC, Paiva SM. Impact of periodontal disease on quality of life: a systematic review. Journal of periodontal research. 2017;52(4):651-65.
6. Buset SL, Walter C, Friedmann A, Weiger R, Borgnakke WS, Zitzmann NU. Are periodontal diseases really silent? A systematic review of their effect on quality of life. Journal of clinical periodontology. 2016;43(4):333-44.
7. Eaton K. The state of oral health in Europe. Platform for Better Oral Health in Europe Brussels; 2012.
8. England N, Improvement N. Commissioning Standard: Dental Care for People with Diabetes. England: NHS England and NHS Improvement. 2019;17(11).
9. Sheiham A. Oral health, general health and quality of life. SciELO Public Health; 2005.
10. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of severe periodontitis in 1990-2010: a systematic review and meta-regression. Journal of dental research. 2014;93(11):1045-53.
11. König J, Holtfreter B, Kocher T. Periodontal health in Europe: Future trends based on treatment needs and the provision of periodontal services - position paper 1. European Journal of Dental Education. 2010;14(SUPPL. 1):4-24.
12. Holtfreter B, Schützhold S, Kocher T. Is Periodontitis Prevalence Declining? A Review of the Current Literature. Epidemiology. 2014;2014.
13. Nazir MA. Prevalence of periodontal disease, its association with systemic diseases and prevention. International Journal of Health Sciences. 2016;1(1).
14. Beukers NG, van der Heijden GJ, van Wijk AJ, Loos BG. Periodontitis is an independent risk indicator for atherosclerotic cardiovascular diseases among 60 174 participants in a large dental school in the Netherlands. Journal of epidemiology and community health. 2017;71(1):37-42.
15. Aimetti M, Perotto S, Castiglione A, Mariani GM, Ferrarotti F, Romano F. Prevalence of periodontitis in an adult population from an urban area in North Italy: findings from a cross-sectional population-based epidemiological survey. Journal of clinical periodontology. 2015;42(7):622-31.
16. World Dental Federation. Global Periodontal Health: Challenges, priorities and perspectives. 2017.
17. OECD. Health at a glance 2016: Europe. State of the health in the EU cycle. OECD Publishing Paris; 2016.
18. Graça SR, Albuquerque TS, Luis HS, Assunção VA, Malmqvist S, Cuculescu M, et al. Oral health knowledge, perceptions, and habits of adolescents from Portugal, Romania, and Sweden: A comparative study. Journal of International Society of Preventive & Community Dentistry. 2019;9(5):470.
19. Billings M, Holtfreter B, Papapanou PN, Mitnik GL, Kocher T, Dye BA. Age-dependent distribution of periodontitis in two countries: Findings from NHANES 2009 to 2014 and SHIP-TREND 2008 to 2012. Journal of periodontology. 2018;89:S140-S58.
20. Catunda RQ, Levin L, Kornerup I, Gibson MP. Prevalence of Periodontitis in Young Populations: A Systematic Review. Oral health & preventive dentistry. 2019;17(3):195-202.
21. Peres KG, Thomson WM, Chaffee BW, Peres MA, Birungi N, Do LG, et al. Oral Health Birth Cohort Studies: Achievements, Challenges, and Potential. Journal of dental research. 2020:22034520942208.
22. Matsuyama Y, Aida J, Tsuboya T, Hikichi H, Kondo K, Kawachi I, et al. Are Lowered Socioeconomic Circumstances Causally Related to Tooth Loss? A Natural Experiment Involving the 2011 Great East Japan Earthquake. American Journal of Epidemiology. 2017;186(1):54-62.
23. Klinge B, Norlund A. A socio-economic perspective on periodontal diseases: a systematic review. Journal of clinical periodontology. 2005;32:314-25.
24. Oral health at a tipping point. The Lancet. 2019.
25. Chapple IL, Van der Weijden F, Doerfer C, Herrera D, Shapira L, Polak D, et al. Primary prevention of periodontitis: managing gingivitis. Journal of clinical periodontology. 2015;42:S71-S6.
26. Ni Riordain R, Glick M, Al Mashhadani SSA, Aravamudhan K, Barrow J, Cole D, et al. Developing a standard set of patient-centred outcomes for adult oral health - an international, cross-disciplinary consensus. International dental journal. 2020.
27. Tonetti MS, Sanz M. Implementation of the new classification of periodontal diseases: Decision-making algorithms for clinical practice and education. Journal of clinical periodontology. 2019;46(4):398-405.
28. Dietrich T, Ower P, Tank M, West NX, Walter C, Needleman I, et al. Periodontal diagnosis in the context of the 2017 classification system of periodontal diseases and conditions - implementation in clinical practice. British dental journal. 2019;226(1):16-22.
29. Emery DC, Cerajewska TL, Seong J, Davies M, Paterson A, Allen-Birt SJ, et al. Comparison of Blood Bacterial Communities in Periodontal Health and Periodontal Disease. Frontiers in cellular and infection microbiology. 2020;10.

30. Sanz M, Marco del Castillo A, Jepsen S, Gonzalez-Juanatey JR, D'Aiuto F, Bouchard P, et al. Periodontitis and cardiovascular diseases: Consensus report. Journal of Clinical Periodontology. 2020;47(3):268-88.
31. Dietrich T, Sharma P, Walter C, Weston P, Beck J. The epidemiological evidence behind the association between periodontitis and incident atherosclerotic cardiovascular disease. Journal of periodontology. 2013;84(4):S70-S84.
32. Ide M, Harris M, Stevens A, Sussams R, Hopkins V, Culliford D, et al. Periodontitis and cognitive decline in Alzheimer's disease. PloS one. 2016;11(3):e0151081.
33. Liccardo D, Marzano F, Carraturo F, Guida M, Femminella GD, Bencivenga L, et al. Potential Bidirectional Relationship Between Periodontitis and Alzheimer's Disease. Frontiers in Physiology. 2020;11.
34. Maldonado A, Laugisch O, Bürgin W, Sculean A, Eick S. Clinical periodontal variables in patients with and without dementia-a systematic review and meta-analysis. Clinical oral investigations. 2018;22(7):2463-74.
35. Nadim R, Tang J, Dilmohamed A, Yuan S, Wu C, Bakre AT, et al. Influence of periodontal disease on risk of dementia: a systematic literature review and a meta-analysis. European Journal of Epidemiology. 2020;35(9):821-33.
36. Chen CK, Wu YT, Chang YC. Association between chronic periodontitis and the risk of Alzheimer's disease: A retrospective, population-based, matched-cohort study. Alzheimer's Research and Therapy. 2017;9(1).
37. Ren H, Du M. Role of maternal periodontitis in preterm birth. Frontiers in Immunology. 2017;8(FEB).
38. Daalderop LA, Wieland BV, Tomsin K, Reyes L, Kramer BW, Vanterpool SF, et al. Periodontal Disease and Pregnancy Outcomes: Overview of Systematic Reviews. JDR clinical and translational research. 2018;3(1):10-27.
39. Puertas A, Magan-Fernandez A, Blanc V, Revelles L, O'Valle F, Pozo E, et al. Association of periodontitis with preterm birth and low birth weight: a comprehensive review. The Journal of Maternal-Fetal & Neonatal Medicine. 2018;31(5):597-602.
40. Moura da Silva G, Coutinho SB, Piscoya MDB, Ximenes RA, Jamelli SR. Periodontitis as a risk factor for preeclampsia. Journal of periodontology. 2012;83(11):1388-96.
41. Xiao L, Zhang Q, Peng Y, Wang D, Liu Y. The effect of periodontal bacteria infection on incidence and prognosis of cancer: A systematic review and meta-analysis. Medicine. 2020;99(15):e19698.
42. Hussain SB, Botelho J, Machado V, Zehra SA, Mendes JJ, Ciurtin C, et al., editors. Is there a bidirectional association between rheumatoid arthritis and periodontitis? A systematic review and meta-analysis. Seminars in arthritis and rheumatism; 2020: Elsevier.
43. Hobbins S, Chapple IL, Sapey E, Stockley RA. Is periodontitis a comorbidity of COPD or can associations be explained by shared risk factors/behaviors? International Journal of COPD. 2017;12:1339-49.
44. Schwendicke F, Giannobile W. Research for Prevention of Oral/Dental Diseases: How Far Have We Come? : SAGE Publications Sage CA: Los Angeles, CA; 2020.
45. Nasseh K, Vujicic M, Glick M. The relationship between periodontal interventions and healthcare costs and utilization. Evidence from an integrated dental, medical, and pharmacy commercial claims database. Health economics. 2017;26(4):519-27.
46. NHS. The NHS Long Term Plan. 2019.
47. Deutsche Diabetes Gesellschaft. Diabetes und Parodontitis: ein gefährliches Duo – Experten raten zur regelmäßigen Zahnarztkontrolle. 2018.
48. Sauver JLS, Carr AB, Yawn BP, Grossardt BR, Bock-Goodner CM, Klein LL, et al. Linking medical and dental health record data: A partnership with the Rochester Epidemiology Project. BMJ open. 2017;7(3).
49. Simon L, Obadan-Udoh E, Yansane A-I, Gharpure A, Licht S, Calvo J, et al. Improving Oral–Systemic Healthcare through the Interoperability of Electronic Medical and Dental Records: An Exploratory Study. Applied clinical informatics. 2019;10(3):367.
50. Ramseier CA, Woelber JP, Kitzmann J, Detzen L, Carra MC, Bouchard P. Impact of risk factor control interventions for smoking cessation and promotion of healthy lifestyles in patients with periodontitis: A systematic review. Journal of Clinical Periodontology. 2020;47(S22):90-106.
51. Slot DE, Valkenburg C, Van der Weijden G. Mechanical plaque removal of periodontal maintenance patients: A systematic review and network meta-analysis. Journal of Clinical Periodontology. 2020;47:107-24.
52. Carra MC, Detzen L, Kitzmann J, Woelber JP, Ramseier CA, Bouchard P. Promoting behavioural changes to improve oral hygiene in patients with periodontal diseases: A systematic review. Journal of Clinical Periodontology. 2020;47(S22):72-89.
53. European Federation of Periodontology. Guidelines for Effective Prevention of Periodontal Diseases: General Guidance. Guidelines for Effective Prevention of Periodontal Diseases: General Guidance, 2015.
54. Public Health England, Department of Health. Delivering better oral health: an evidence-based toolkit for prevention. London: Public Health England, 2017.
55. The Department of Health. The Expert patient: A new approach to chronic disease management for the twenty-first century. 2001.
56. Shah S, Wordley V. An overview of adult dental fee exemptions in NHS primary dental care in England. British Dental Journal. 2021:1-5.
57. Steele J, Shen J, Tsakos G, Fuller E, Morris S, Watt R, et al. The Interplay between socioeconomic inequalities and clinical oral health. Journal of dental research. 2015;94(1):19-26.
58. Liccardo D, Cannavo A, Spagnuolo G, Ferrara N, Cittadini A, Rengo C, et al. Periodontal disease: A risk factor for diabetes and cardiovascular disease. International Journal of Molecular Sciences. 2019;20(6).
59. Folayan MO, El Tantawi M, Aly NM, Al-Batayneh OB, Schroth RJ, Castillo JL, et al. Association between early childhood caries and poverty in low and middle income countries. BMC oral health. 2020;20(1):1-8.
60. Hall-Scullin E, Whitehead H, Milsom K, Tickle M, Su T-L, Walsh T. Longitudinal study of caries development from childhood to adolescence. Journal of dental research. 2017;96(7):762-7.

61. Aliakbari E, Gray-Burrows KA, Vinall-Collier KA, Edwebi S, Marshman Z, McEachan RR, et al. Home-based toothbrushing interventions for parents of young children to reduce dental caries: A systematic review. International journal of paediatric dentistry. 2021;31(1):37-79.
62. Gray-Burrows K, Day P, Marshman Z, Aliakbari E, Prady S, McEachan R. Using intervention mapping to develop a home-based parental-supervised toothbrushing intervention for young children. Implementation science. 2015;11(1):1-14.
63. Kidd JB, McMahon AD, Sherriff A, Gnich W, Mahmoud A, Macpherson LM, et al. Evaluation of a national complex oral health improvement programme: a population data linkage cohort study in Scotland. BMJ open. 2020;10(11):e038116.
64. Marshman Z, Ahern S, McEachan R, Rogers H, Gray-Burrows K, Day P. Parents' experiences of toothbrushing with children: a qualitative study. JDR Clinical & Translational Research. 2016;1(2):122-30.
65. Affordable Health Initiative. Affordable Health Initiative.
66. MACIEL IPB, M.B.; LEAL, S.C.; MARCENES, W. Assessment of the implementation of the AHI Health Promoting School model. J Dent Res. In press, 2021.
67. PIOVESAN ÉTAL, S.C.; MARCENES, W. An implementation research protocol to assess Health Promoting Schools impact. In: IADR/AADR/CADR General Session. J Dent Res. In press 2021.
68. Sheiham A, Netuveli GS. Periodontal diseases in Europe. Periodontology 2000. 2002;29(1):104-21.
69. Chan M, editor WHO Director-General addresses health promotion conference. Opening address at the 8th Global Conference on Health Promotion Helsinki; 2013.
70. Hazen C. Sugary drink FACTS 2014: Some progress but much room for improvement in marketing to youth: Rudd Center for Food Policy and Obesity; 2014.
71. de Lacy-Vawdon C, Livingstone C. Defining the commercial determinants of health: a systematic review. BMC public health. 2020;20(1):1-16.
72. Watt RG, Daly B, Allison P, Macpherson LM, Venturelli R, Listl S, et al. The Lancet oral health series: Implications for oral and dental research. Journal of dental research. 2020;99(1):8-10.
73. Citizens Advice Bureaux. Charging for health. 2001.
74. Listl S, Galloway J, Mossey PA. Global economic impact of dental diseases. Journal of Dental Research. 2015;94(10).
75. Hayes A, Azarpazhooh A, Dempster L, Ravaghi V, Quiñonez C. Time loss due to dental problems and treatment in the Canadian population: analysis of a nationwide cross-sectional survey. BMC Oral Health. 2013;13(1):1-11.
76. World Health Organization. Study protocol for the World Health Organization project to develop a Quality of Life assessment instrument (WHOQOL). Qual Life Res. 1993;2(2):153-9.
77. El Sayed N, Baeumer A, El Sayed S, Wieland L, Weber D, Eickholz P, et al. Twenty years later: Oral health-related quality of life and standard of treatment in patients with chronic periodontitis. Journal of periodontology. 2019;90(4):323-30.
78. York Health Economics Consortium. A rapid review of evidence on the cost-effectiveness of interventions to improve the oral health of children aged 0-5 years. London: Public Health England, 2016.
79. Kent Surrey Sussex Academic Health Science Network. Cost benefit analysis ofthe Mouth Care Matters programme Kent Surrey Sussex Academic Health Science Network, 2017.
80. Schwendicke F, Engel AS, Graetz C. Long-term treatment costs of chronic periodontitis patients in Germany. Journal of clinical periodontology. 2018;45(9):1069-77.
81. Vallejo-Torres L, García-Lorenzo B, Castilla I, Valcárcel-Nazco C, García-Pérez L, Linertová R, et al. On the estimation of the cost-effectiveness threshold: why, what, how? Value in Health. 2016;19(5):558-66.
82. Cameron D, Ubels J, Norström F. On what basis are medical cost-effectiveness thresholds set? Clashing opinions and an absence of data: a systematic review. Global health action. 2018;11(1):1447828.
83. Robinson LA, Hammitt JK, Chang AY, Resch S. Understanding and improving the one and three times GDP per capita cost-effectiveness thresholds. Health Policy and Planning. 2017;32(1):141-5.
84. World Health Organization. Optimizing health worker roles to improve access to key maternal and newborn health interventions through task shifting. 2012.
85. Council of European Dentists. Manual of Dental Practice 2015. 2015.
86. Direction de l'Information légale et administrative (Premier Ministre). Remboursement des soins dentaires. 2021.
87. Ministero della Salute. Malattia parodontale. 2013.
88. den Boer JC, van der Sanden WJ, Bruers JJ. Developments in oral health care in the Netherlands between 1995 and 2018. BMC Oral Health. 2020;20(1):1-12.
89. Consejo de Dentistas de España. La Salud Bucodental en España. 2020.
90. NHS. Understanding NHS dental charges. 2020.
91. World Health Organization. Global Health Observatory 2021. Available from: https://www.who.int/data/gho.
92. Caro JJ, Briggs AH, Siebert U, Kuntz KM. Modeling good research practices—overview: a report of the ISPOR-SMDM Modeling Good Research Practices Task Force–1. Medical Decision Making. 2012;32(5):667-77.
93. Herrera D, Alonso B, de Arriba L, Santa Cruz I, Serrano C, Sanz M. Acute periodontal lesions. Periodontology 2000. 2014;65(1):149-77.
94. Murillo G, Vargas MA, Castillo J, Serrano JJ, Ramirez GM, Viales JH, et al. Prevalence and Severity of Plaque-Induced Gingivitis in Three Latin American Cities: Mexico City-Mexico, Great Metropolitan Area-Costa Rica and Bogota-Colombia. Odovtos-International Journal of Dental Sciences. 2018;20(2):91-102.
95. Davidovich E, et al. Plaque Removal by a Powered Toothbrush Versus a Manual Toothbrush in Children: A Systematic Review and Meta-Analysis Pediatr Dent . 2020 Jul 15;42(4):280-287.
96. Van der Weijden FA, et al. Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis a meta review. J Clin Periodontol . 2015 Apr;42 Suppl 16:S77-91. doi: 10.1111/jcpe.12359.

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