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Oral diseases: a global public health challenge

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Oral diseases are among the most prevalent diseases globally and have serious health and economic burdens, greatly reducing quality of life for those affected. The most prevalent and consequential oral diseases globally are dental caries (tooth decay), periodontal disease, tooth loss, and cancers of the lips and oral cavity. In this first of two papers in a Series on oral health, we describe the scope of the global oral disease epidemic, its origins in terms of social and commercial determinants, and its costs in terms of population wellbeing and societal impact. Although oral diseases are largely preventable, they persist with high prevalence, reflecting widespread social and economic inequalities and inadequate funding for prevention and treatment, particularly in low-income and middle-income countries (LMICs). As with most non-communicable diseases (NCDs), oral conditions are chronic and strongly socially patterned. Children living in poverty, socially marginalised groups, and older people are the most affected by oral diseases, and have poor access to dental care. In many LMICs, oral diseases remain largely untreated because the treatment costs exceed available resources. The personal consequences of chronic untreated oral diseases are often severe and can include unremitting pain, sepsis, reduced quality of life, lost school days, disruption to family life, and decreased work productivity. The costs of treating oral diseases impose large economic burdens to families and health-care systems. Oral diseases are undoubtedly a global public health problem, with particular concern over their rising prevalence in many LMICs linked to wider social, economic, and commercial changes. By describing the extent and consequences of oral diseases, their social and commercial determinants, and their ongoing neglect in global health policy, we aim to highlight the urgent need to address oral diseases among other NCDs as a global health priority.

Introduction

Oral health matters. The teeth and mouth are an integral part of the body, supporting and enabling essential human functions, and the mouth is a fundamental feature of personal identity. Building on existing definitions,^{1,2} oral health can be defined as being multidimensional in nature, including physical, psychological, emotional, and social domains that are integral to overall health and wellbeing. Oral health is subjective and dynamic, enabling eating, speaking, smiling, and socialising, without discomfort, pain, or embarrassment. Good oral health reflects an individual's ability to adapt to physiological changes throughout life and to maintain their own teeth and mouth through independent self care. Despite being largely preventable, oral diseases are highly prevalent throughout the life course and have substantial negative effects on individuals, communities, and the wider society. Oral diseases are a global public health problem, with particular concern over their rising prevalence in many low-income and middle-income countries (LMICs), linked to wider social, economic, and commercial changes.^{3,4}

Oral diseases are chronic and progressive in nature. For example, dental caries (tooth decay) affects very young children, but is a lifelong condition that tracks across adolescence and adulthood, and into later life. Oral conditions disproportionately affect impoverished and socially disadvantaged members of society. A strong and consistent social gradient exists between socioeconomic status and the prevalence and severity of oral diseases. In this way, oral diseases can be considered as a sensitive clinical marker of social disadvantage, being an early

indicator of population ill health linked to deprivation.⁵ Oral diseases and oral health inequalities are directly influenced by wider social and commercial determinants, which are the underlying drivers of poor population oral health.⁶

Key messages

- Oral health is an integral element of overall health and wellbeing, enabling essential daily functions
- Oral diseases include a range of chronic clinical conditions that affect the teeth and mouth, including dental caries (tooth decay), periodontal (gum) disease, and oral cancers
- Despite being largely preventable, oral diseases are highly prevalent conditions, affecting more than 3·5 billion people around the world; dental caries is the most common disease globally with increasing prevalence in many low-income and middle-income countries
- Oral diseases disproportionately affect poorer and marginalised groups in society, being closely linked to socioeconomic status and the broader social determinants of health
- Oral diseases have substantial effects, causing pain, sepsis, reduced quality of life, lost school days, family disruption, and decreased work productivity, and the costs of dental treatment can be considerable for both the individual and the wider health-care system
- Oral conditions share common risk factors with other non-communicable diseases, which include free sugar consumption, tobacco use, and harmful alcohol consumption, as well as the wider social and commercial determinants of health
- Of particular concern is the effect of free sugar consumption on the prevalence of caries and overweight or obesity, and associated conditions such as diabetes
- Recognition is increasing of the influence, power, and effect of the global sugar industry as a threat to public health, which requires tighter regulation and legislation by governments

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This is the first in a **Series** of two papers about oral health

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However, oral diseases are a neglected issue, rarely seen as a priority in health policy.⁷ Oral health and the dental profession have become somewhat isolated and marginalised from mainstream developments in health policy and health-care systems. The current model of dental care delivery and clinical preventive policy does not tackle the global burden of oral diseases. The so-called westernised model of modern dentistry (high technology and treatment focused) is unaffordable and inappropriate in many LMICs.⁸ Even in settings with resources, dentistry is not meeting the needs of large segments of the national population and is increasingly focusing on the provision of aesthetic treatments, largely driven by profit motives and consumerism.⁹ A radically different approach is needed to tackle the global challenge of oral diseases.

In this first paper of a two-part Series on oral health,¹⁰ we highlight the evidence for the global clinical and public health importance of oral diseases in terms of their prevalence, patterns of oral health inequalities, and effects on individuals, families, and society. Our analysis also highlights the underlying social and commercial determinants—the broad range of interacting biological, behavioural, psychosocial, economic, corporate, and political drivers that create the “conditions in which people are born, grow, live, work and age”¹¹ that cause poor population oral health.^{6,11} Furthermore, we present a unifying framework that places oral diseases in a broader context and directly links them to other non-communicable diseases (NCDs).

Clinical overview of oral diseases

A wide range of diseases and disorders affect the soft and hard tissues of the mouth, including an array of craniofacial disorders, congenital anomalies, injuries, and various infections. However, the key clinical conditions that are considered to be global public health priorities include dental caries (tooth decay), periodontal (gum) disease, and oral cancers.

Dental caries

Dental caries is the localised destruction of dental hard tissues (enamel and dentine) by acidic by-products from the bacterial fermentation of free sugars^{12,13} (defined as monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, and sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates¹⁴). The caries process is dynamic, with alternating periods of demineralisation and remineralisation of the tooth structure related to fluctuations in the pH of the plaque biofilm. In general, the lower the pH, the greater the tendency for dissolution of the hard tissue components. If the pH in the biofilm falls below a critical threshold for a sustained period following the consumption of free sugars, the result is progressive demineralisation and sustained loss of calcium and phosphate from the mineral substance of the

tooth. In the very early (subclinical) stages, and even once sufficient mineral is lost for the lesion to appear clinically as a white spot on the tooth surface, caries can be reversed or arrested, especially with exposure to fluoride.^{15,16} If caries progresses and leads to cavitation, the condition can cause considerable pain and discomfort, and, if it spreads to the dental pulp, can also cause infection, and ultimately sepsis and tooth loss. Optimal exposure to fluoride is important in limiting disease progression as fluoride promotes remineralisation. Cavitation is the usual criterion for caries detection in most epidemiological studies worldwide. The most commonly used dental caries index is the Decayed, Missing and Filled Teeth (DMFT) index, which counts the number of decayed, missing, and filled teeth resulting from dental caries (with lowercase letters representing primary dentition and capital letters representing permanent dentition).¹⁷ The DMFT index thus captures an individual's cumulative experience of past and present dental caries, whether untreated (the number of decayed teeth) or treated (filled teeth or missing teeth extracted because of caries).

Periodontal diseases

Periodontal diseases are chronic inflammatory conditions that affect the tissues surrounding and supporting the teeth. Initially, periodontal disease presents as gingivitis, a reversible inflammation of the periodontal soft tissues resulting in gingival bleeding and swelling. In susceptible individuals with a compromised immune response, gingivitis might lead to periodontitis, which progressively destroys the periodontal tissue support, including the bone surrounding the teeth.¹⁸ Periodontitis is characterised by this loss of periodontal tissue support, manifesting as clinical attachment loss, the presence of periodontal pocketing, gingival bleeding, and radiographically assessed alveolar bone loss. The main cause of periodontal disease is poor oral hygiene leading to an accumulation of pathogenic microbial biofilm (plaque) at and below the gingival margin.^{19,20} Tobacco use is also an important independent risk factor for periodontal disease. Through the sharing of a common inflammatory pathway, periodontal disease is associated with other chronic diseases including diabetes, cardiovascular diseases, and dementia.^{21–24} In older adults, periodontal disease has been causally linked with aspiration pneumonia, which often results in serious morbidity and mortality.²⁵ Periodontitis can ultimately lead to tooth loss and negatively affects chewing function, aesthetics, and quality of life.

Oral cancers

Cancer of the lips and oral cavity is a broad category of localisation for a neoplasm, defined by the International Classification of Disease, 10th Revision, as cancer of the lips, tongue, gum, floor of mouth, palate, cheek mucosa, vestibule of the mouth, or retromolar area (malignant neoplasm topography codes C00–C06).²⁶ Squamous cell carcinoma is the most common type of oral cancer. The

major risk factors for oral cancers are tobacco use, alcohol consumption, and areca nut (betel quid) chewing.^{27–29} In many high-income countries (HICs), human papilloma virus infection is responsible for a steep rise in the incidence of oropharyngeal cancers among young people.³⁰ The prevalence of oral cancers is greater among men, older age groups, and individuals from poorer backgrounds, with socioeconomic inequalities observed both between and within countries.³¹

Global epidemiological overview of oral diseases

According to the Global Burden of Disease (GBD) 2015 study, around 3·5 billion people worldwide live with dental conditions, predominantly untreated dental caries in the deciduous and permanent dentitions, severe periodontal disease, edentulism (complete tooth loss), and severe tooth loss (having between 1 and 9 remaining teeth).³ According to the International Agency for Research on Cancer, lip and oral cavity cancers were among the top 15 most common cancers in the world in 2018.²⁶

Dental caries

Epidemiological evidence indicates that lifetime prevalence of dental caries has decreased in the past four decades, but this is mainly in HICs, with the most substantial decrease seen in 12-year-old children.^{32,33}

Evidence on the burden of untreated caries in deciduous teeth stems from 192 studies involving a total of 1502 260 children aged 1–14 in 74 countries, according to GBD 2015.³ In 2010, untreated caries in deciduous teeth was the tenth most prevalent health condition, affecting 9·0% of the global child population; the global age-standardised prevalence remained unchanged between 1990 and 2010 (9·0%);³⁴ and the age-standardised global incidence was 15 205 cases per 100 000 person-years in

2010, which was slightly and non-significantly less than the 15 437 cases per 100 000 person-years reported in 1990.³⁵ In 2015, the prevalence of untreated caries in deciduous teeth was 7·8%; and the age-standardised prevalence estimates in 2015 were similar to the 1990 estimates. Untreated caries in deciduous teeth peaked among children aged 1–4 years in 2015.³

Untreated caries in permanent teeth was the most prevalent health condition in 2010, affecting 35% of the global population, or 2·4 billion people worldwide.³⁵ These and other data on disease burden came from 186 studies enrolling a total of 3 265 546 individuals aged 5 years or older in 67 countries. Between 1990 and 2010, the global age-standardised prevalence remained stable at around 35%. In 2010, the age-standardised incidence was 27 257 cases per 100 000 person-years, which was non-significantly different from the 1990 estimate of 28 689 cases per 100 000 person-years. Prevalence reached peak in 1990 and 2010; the first and largest peak was at age 25 years and a second smaller peak occurred at around age 70 years, with the later peak probably explained by increased root caries. The most recent data from 2015 confirmed that untreated caries in the permanent dentition remained the most common health condition globally (34·1%). In contrast to the earlier data, the peak prevalence of untreated dental caries in the permanent dentition was seen in the younger age group of 15–19 years in 2015.³ Figure 1 shows the updated GBD estimates for 2017 of the prevalence of untreated dental caries in permanent teeth per 100 000 population of each country, obtained via the Institute of Health Metrics and Evaluation GBD Compare tool. Only a 4% decrease in the number of prevalent cases of untreated dental caries occurred globally from 1990 (31 407 cases per 100 000) to 2017 (30 129 cases per 100 000). The global distribution

For more on the Institute of Health Metrics and Evaluation GBD Compare tool see <https://vizhub.healthdata.org/gbd-compare/>

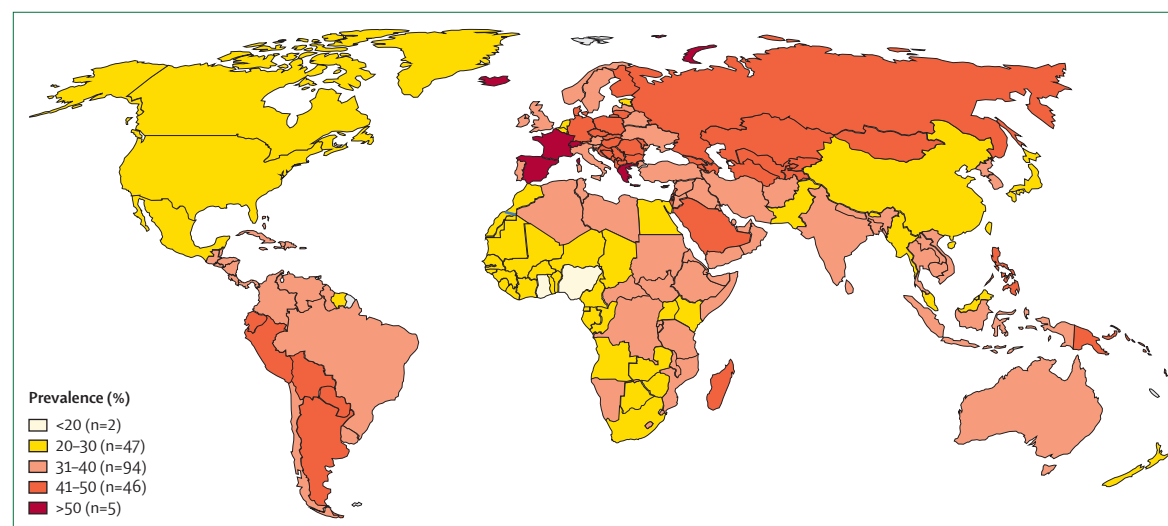


Figure 1: Estimated global prevalence of untreated dental caries in permanent teeth for 2017

Shown are updated age-standardised GBD estimates for 2017, obtained and visualised via the Institute of Health Metrics and Evaluation GBD Compare tool. GBD=Global Burden of Disease. n=number of countries.

and intercountry variations in prevalence changed marginally during this period.

Thus, overall, the global burden of untreated dental caries for primary and permanent dentition has remained relatively unchanged over the past 30 years, challenging the conventional view that the burden of dental caries has generally improved.

Periodontal diseases

Case definition of periodontal disease in epidemiological studies is a challenge, but is generally based on measures of probing periodontal pocket depth and clinical attachment loss. In 2010, severe periodontitis was the sixth-most prevalent health condition, affecting 10·8% of people, or 743 million, worldwide. The global age-standardised prevalence and incidence have remained stable since 1990: in 1990, prevalence was at 11·2% and incidence at 696 cases per 100 000 person-years, compared with a prevalence of 10·8% and an incidence of 701 cases per 100 000 person-years in 2010.³⁶

Tooth loss

Tooth loss reflects the endpoint of a lifetime of dental disease—usually dental caries or periodontal diseases—and the individual's history of (or absence of) dental treatment. In 2010, 158 million people, or 2·3% of the global population, were completely edentulous (no natural teeth). Prevalence of severe tooth loss reduced between 1990 and 2010, declining from 4·4% to 2·4%. Global incidence also decreased from 374 cases per 100 000 person-years in 1990 to 205 cases per 100 000 person-years in 2010.³⁷

Oral cancer

Lip and oral cavity cancers are among the top 15 most common cancers worldwide, with 500 550 incident cases in 2018.²⁶ The total number of deaths due to cancer of the lip and oral cavity was 177 384 (67% of deaths in males) in 2018, or an age-standardised rate (ASR) of 2·8 per 100 000 males and 1·2 per 100 000 females. Data from 2018 show that oral cancer has the highest incidence among all cancers in Melanesia and south Asia among males, and is the leading cause of cancer-related mortality among males in India and Sri Lanka.²⁶ Furthermore, among males living in countries with a low or medium Human Development Index, the ASR of oral cancer is the fourth highest of all cancers (ASR of 8·7 per 100 000 males).²⁶

Socioeconomic inequalities in oral health

Stark and persistent socioeconomic inequalities exist in the prevalence of oral diseases in a consistent and graded manner across the social hierarchy, serving as a classic example of a social gradient in health. These inequalities have been extensively described in the literature and some studies from the past few years (with quasi-experimental methods) have highlighted causal relationships between socioeconomic status and oral health.³⁸

A 2015 systematic review assessed the association between socioeconomic position and caries experience in 155 studies involving a total of 329 798 participants.³⁹ The association between low educational background and having experienced caries was significantly higher in countries with high Human Development Index scores (>0·8), relative to countries with low index scores, even after adjustment for potential confounders. Lower socioeconomic position was also significantly associated with having untreated caries lesions or any caries experience.³⁹ In an update to this review, Costa and colleagues⁴⁰ identified associations between poor socioeconomic status and severe dental caries among adults in highly developed countries; an increase in one unit of socioeconomic status level was associated with an increase in 10·35 DMFT score units. Additionally, Klinge and Norlund⁴¹ identified that disadvantaged socioeconomic circumstances were associated with poor periodontal health, even after controlling for smoking, a well known risk factor for periodontal disease. Further evidence from a systematic review of case-control studies showed a consistent association between low socioeconomic status and oral cancer in both LMICs and HICs, even after adjustment for behavioural confounders.⁴²

Studies of socioeconomic inequalities in dental caries over the life course of individuals are rare, and have mostly focused on population-based birth cohorts from New Zealand (Dunedin) and Brazil (Pelotas). Findings from the Dunedin study showed that untreated dental caries in adulthood were negatively associated with childhood socioeconomic status.⁴³ With increasing socioeconomic status, the amount of poor oral health indicators decreased, even after controlling for childhood health and adult socioeconomic position. Furthermore, low adult socioeconomic status had a significant effect on poor adult dental health after controlling for low childhood socioeconomic status.⁴³ Findings from the Pelotas birth cohort study showed that poverty in at least one stage of early life (0 to 15 years) had an effect on dental caries experience, oral health-related behaviours, and dental service use at age 15 years.⁴⁴ At age 24 years, the study findings revealed that poverty experienced in early life was associated with unsound teeth.⁴⁵ In Sweden, most socioeconomic inequalities in self-reported dental health were already present early in life and remained in older age (>85 years).⁴⁶

Marginalised groups and disability

Extreme oral health inequalities exist for the most marginalised and socially excluded groups in societies, such as homeless people, prisoners, those with long-term disabilities, refugees, and indigenous groups, which serves as a classic example of a so-called cliff-edge of inequality⁴⁷ (figure 2). Homeless people living in HICs have more untreated dental caries, more severe tooth loss, and are more likely to experience toothache than

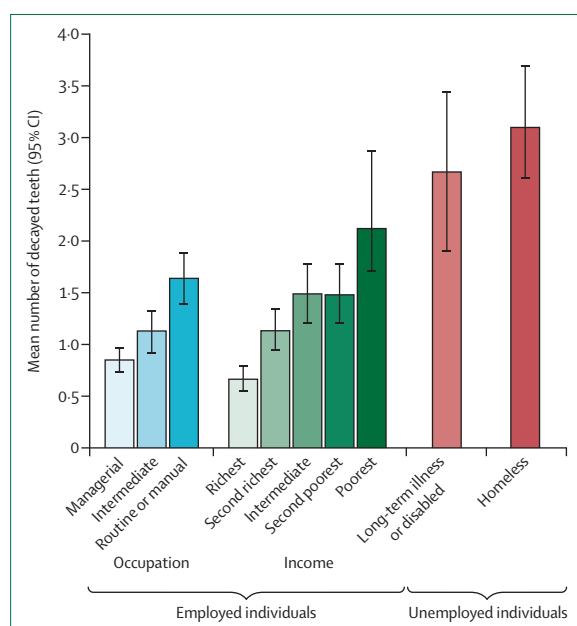


Figure 2: Mean number of decayed teeth among male adults aged 16–65 years in England, Wales, and Northern Ireland

Data on occupation, income, and long-term illness and disability are from the Adult Dental Health Survey, 2009.⁴⁸ Information on homeless participants is from Daly et al.⁴⁹ The data presented are for men only as aged matched data were available for very few women recruited into the homeless study, reflecting the gender distribution of homelessness at the time of the study. Categories for employed individuals are based on National Statistics Socio-economic Classifications; income ranges are split into quintiles.

the general population.^{49–53} Prisoners also have very poor oral health.^{54–59} A study in the USA reported that prisoners had 8.4 times more untreated caries than non-institutionalised US adults.⁶⁰ In prisoners, the unmet treatment need is further complicated by restricted access to dental care.^{57–59} The situation for homeless people and prisoners in low-income countries is less documented. Disability in the context of oral health can be understood as a disability or an activity restriction that directly or indirectly affects oral health, and which is situated within the personal and environmental context of the individual.⁶¹ Worldwide, people living with a wide range of disabilities have been shown to experience greater unmet dental need, including more untreated caries, than the general population.⁶² Indigenous children, even in HICs (Australia, Canada, New Zealand, and the USA), are particularly vulnerable, with the prevalence of early childhood caries ranging from 68% to 90%.⁶³ Schroth and colleagues⁶⁴ highlighted that indigenous child populations have a higher prevalence of early childhood caries and that the disease is generally more severe than in non-indigenous populations. Adults and older people from indigenous populations also have very poor oral health and high treatment needs,^{65–68} a problem compounded by the fact that often these communities live in rural and remote areas where access to dental care is very poor.^{68,69}

Effects of oral diseases on individuals, families, and society

Economic burden of oral diseases

Dental diseases impose a substantial economic burden on society.⁷⁰ Their economic burden encompasses direct costs (treatment expenditures), indirect costs (productivity losses due to absence from work and school), and intangible costs (eg, pain, problems with biting, chewing and eating, tasting, speaking, and the expression of emotions such as smiling, all of which are involved in social and family activities). Worldwide in 2015, dental diseases accounted for US\$356.80 billion in direct costs and US\$187.61 billion in indirect costs.⁷¹ In a comparison of expenditures on various diseases in the 28 EU member states in 2015 (appendix pp 1–2), dental diseases (€90 billion) ranked third behind diabetes (€119 billion) and cardiovascular diseases (€111 billion).

See Online for appendix

Dental diseases might also exacerbate the burden of other diseases and thereby contribute to the economic burden of these conditions. For example, periodontal disease has been linked to poor glycaemic control among diabetes patients.²² For such patients, periodontal treatment has been shown to reduce total and diabetes-related health-care costs.⁷²

Children

The toothache that follows on from untreated caries is persistent and often severe.^{73–75} In a review of seven studies, Slade found that the prevalence of dental pain ranged from 5% to 33%, and increased with child age, caries severity, and decreasing socioeconomic status.⁷³ Many children from LMICs and from indigenous populations in HICs have been shown to have a lifetime history of dental pain.^{76–81}

Dental problems can result in lost time from school and have a negative effect on school performance, possibly exacerbating social inequalities.^{4,82–88} Numerous studies show that untreated dental caries and associated oral problems substantially decrease quality of life for the child and their caregivers.^{89–94}

For young children with extensive dental caries, treatment under general anaesthesia is often the only realistic approach. Such care is expensive and usually only viable in HICs. Two US studies indicated that the average cost of dental treatment under general anaesthesia varied between over US\$5500 (in 2008) and US\$7303 (in 2012) per child.⁹⁵ Globally, few data exist that document the use of general anaesthesia to treat dental diseases. Schroth and colleagues⁶⁴ reported that day surgery to treat early childhood caries among Canadian children younger than 6 years occurred at a rate of 12.1 per 1000 children and accounted for 31% of all day surgeries done in this age group. In Australia, between 2011 and 2012, the total number of hospital procedures needing a general anaesthetic because of dental reasons among children younger than 5 years reached 7890 (8.1% of the total number of procedures needing general anaesthetic).⁹⁶

Adults

Many adults have poor access to dental care, which means they also have to cope with acute and chronic dental pain and diminished quality of life.⁹⁷ Population-based studies found the 4-week prevalence of all cause orofacial pain to be 26% in the UK⁹⁸ and 53% in Canada.⁹⁹ A 2012 report from Brazil estimated that nearly 25% of the adult population had experienced dental pain within the previous 6 months.¹⁰⁰

In many countries, access to dental care for adults is often challenging, as the financing and care delivery models are often more restricted (in terms of budget and services) than for medical care. The USA is a good example, where adult dental care for low-income individuals has minimal public funding. The result is that many patients wait until their dental problems become painful, or serious infections develop, which then drives them into hospital emergency departments for urgent care. In the USA, a 16% increase in emergency department visits for dental conditions occurred between 2006 and 2009, with nearly 1 million patient visits in 2009.¹⁰¹ Unfortunately, emergency departments are usually not equipped to address oral problems other than orofacial trauma, and thus services are limited to palliative measures such as temporary pain management with opioids.¹⁰²

National surveys of oral health-related quality of life done in several western European countries, Australia, and the USA show that dental conditions all contribute to lower life satisfaction.^{102–108} In adults, orofacial pain is common and is the most consistent contributor to decreased quality of life globally.¹⁰⁹

A small number of studies have provided evidence on the social cost of oral conditions in terms of the negative effects on employment status and work productivity.¹¹⁰ A nationwide study done in Canada found that dental-related issues resulted in an average of 3·5 hours of lost working time per person per year, adding to a national total of 40 million lost work hours, which they estimated led to a productivity loss of over CAN\$1 billion.¹¹¹ A study from the USA has suggested beneficial effects of good oral health on earning capacities of women in the labour market.¹¹² A nationally representative study of employed adults in Australia found that 9% of employed people missed one or more half days in a year due to dental problems, with lost productivity costs of AUS\$660 million.¹¹³ In a regional survey of working adults in Brazil, Nardi and colleagues¹¹⁴ reported that orofacial pain led to 15% of respondents being absent from work in the 6 months prior to the survey. In an interventional study in the USA, Hyde and colleagues¹¹⁵ found that unemployed people receiving welfare support who had been unsuccessfully seeking employment for at least 3 months and who completed a course of dental treatment were twice as likely to achieve satisfactory employment after the dental care, compared with those who did not receive any care.

Older adults

As a consequence of changes in some health-related behaviours, such as a reduction in smoking and widespread use of fluoride toothpastes, adults in many HICs are retaining more of their natural dentition as they age.³⁷ Although this outcome is desirable, many of the teeth now being retained into older age (eg, over 65 years) have longstanding dental restorations and, in most older adults, have some degree of advanced periodontal disease.³³

This rise in tooth retention into older age has led to an increased need for more complex restorative care for a growing number of older adults.¹¹⁶ However, because of restrictions in public funding for adult dental services, treatment costs are a substantial barrier to care.¹¹⁷ Additionally, many dentists are not well trained in providing care for patients with complex medical problems.¹¹⁸ Reduced mobility and transportation difficulties associated with older age are adding to the challenge of accessing oral health care.¹¹⁹ The result tends to be lower dental service use among older people, leading to an accumulation of untreated dental conditions or a late-stage disease diagnosis and, thus, a poor prognosis. Community-dwelling older people report similar concerns to working-age adults regarding their oral health. These concerns include a high perceived need for dental care,¹²⁰ associated problems with pain, eating, and oral comfort,¹²¹ and problems with the use of dentures.¹²² Poor oral health in later life has also been shown to affect social relationships and loneliness^{123,124} and to lead to poor nutrition.¹²⁵

Social and commercial determinants of oral diseases

The WHO conceptual framework for action on the social determinants of health¹²⁶ highlights how structural determinants, such as economic, social, and welfare policies, can generate social hierarchies and influence the socioeconomic status of individuals within societies. Socioeconomic status can then influence health through the circumstances in which people live, work, and age, and their risks for disease. These intermediate determinants include housing and working conditions, social capital, psychosocial factors such as stress and social support, and access to health care.

Although the social determinants of health have been well known for some time, the implementation of policies to address these determinants has been slow. The dental public health community has been advocating the importance of integrated upstream and community-based approaches;¹²⁷ however, oral health care and approaches to disease prevention still operate to a large extent in a non-integrated dental silo. Dental policy makers tend to rely on simplistic downstream interventions; in part, because of the dominance of a clinical interventionist philosophy, and because of the challenges of generating evidence of efficacy for the more complex

upstream interventions. The biomedical approach to prevention thus prevails and shapes policies that favour the delivery of clinical preventive interventions and chair-side oral health advice, rather than population-wide upstream strategies.

A number of models have conceptually adapted the WHO social determinants framework for oral health.^{6,128,129} Additionally, recognition is growing^{130,131} for the need to move from current clinical approaches to policy initiatives that tackle oral health inequalities at the structural level, focusing on the social determinants of health and the risk factors shared between oral diseases and other NCDs, such as free sugar consumption, tobacco use, alcohol consumption, and their wider driving determinants.⁶

Globally, a steady overall increase has occurred in the production of sucrose (sourced from sugar beet and sugar cane), the most widely available sweetener since the 1980s (appendix p 3). As a consequence, in many LMICs, prevalence of dental caries is increasing at the same time as reported marked increases in the consumption of sugars^{34,132} including sugary drinks.^{133,134} Economic development in many LMICs has moved millions out of poverty, resulting in a rapid demographic and nutritional transition characterised by some adverse changes in diet, physical activity, and health.^{5,132} Multinational corporations are expanding their reach from near-saturated markets in HICs, to also target new opportunities in emerging economies. The increased availability of unhealthy consumer goods, including high-sugar foods and drinks, is shifting behaviours and contributing to the increase in NCDs.¹³⁵ This overall shift represents a potential minefield of future harms, with poorer health resulting in reduced productivity and burgeoning health-care costs. Buse and colleagues¹³⁶ highlighted that “We cannot treat our way out of the NCD epidemic.” We agree with their view that a radically different approach is needed.

Hastings¹³⁷ has argued that equal concern now needs to be focused on the commercial as well as the social determinants of health. Commercial determinants of health are defined as “strategies and approaches used by the private sector to promote products and choices that are detrimental to health.”¹³⁵ In 2013, WHO Director-General, Dr Margaret Chan, stated that “Efforts to prevent non-communicable diseases go against the business interests of powerful economic operators. In my view, this is one of the biggest challenges facing health promotion.”¹³⁸ The profit margins for transglobal corporations are immense compared with the public finances available for health improvement interventions.¹³⁶ Particularly relevant for oral health policies is the case of the global sugar industry (panel). The tactics used by the sugar industry include discrediting major research and recommendations on diet and nutrition, enlisting the support of politicians to block reports and policy, and funding ostensibly independent organisations to obtain access to key decision makers and to legitimise statements downplaying the role of sugars in the aetiology of disease.^{141,148–150} In 2018, a scoping review¹⁵¹

identified methods by which corporate interests can “drive research agendas away from questions that are most relevant for public health”. The authors called for the development of strategies to counteract the influence of industry sponsorship on research.

Four channels through which transnational corporations can negatively influence health have been proposed. Firstly, through marketing that aims to enhance the desirability and acceptability of products; secondly, via lobbying, to influence public health policy and legislation; thirdly, by using corporate responsibility strategies to enhance the acceptability of the producers via activities such as sponsorship of sporting events and health-care initiatives; and finally, through globally extended supply chains.¹³⁵ We present a conceptual framework combining the social and commercial determinants of oral health to highlight the interacting influences and processes (figure 3).^{6,126}

Advertising to children is extensive and possible via multiple channels, and can have profound effects on

For more on the World Bank gross domestic product data (current US\$) see <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD>

Panel: The power and influence of Big Sugar

The global sugar industry provides an incisive example of the commercial determinants of health in action. Although free sugars are used in the production of many processed foods and drinks, soft drinks are a major source of sugar in the global diet. The international soft drinks market is dominated by a small number of companies—in particular, Coca-Cola and PepsiCo. These two companies alone account for over a third of worldwide soft drinks sales¹³⁹ with accumulated revenues in excess of US\$100 billion in 2014,¹⁴⁰ a sum that exceeds the gross domestic product even of high-income countries (HICs) among a total of 125 countries globally according to data from the World Bank. Commercial economic power readily translates into political power and policy influence.¹⁴¹ Between 2009 and 2015, Coca-Cola, PepsiCo, and the American Beverage Association spent \$114 million lobbying at the US federal level.^{135,142} In 2003, after a joint expert committee recommended limiting free sugars to less than 10% of total energy intake in an advisory report¹⁴³ commissioned by WHO and the UN Food and Agriculture Organization, the global sugar industry successfully lobbied the WHO Director-General to exclude the recommendation from the WHO’s 2004 Global Strategy on Diet, Physical Activity and Health.¹⁴⁴ Among other tactics, the US Sugar Association, working through two US senators, warned of getting the US funding for WHO (US\$406 million) withdrawn.¹⁴⁵

The soft drinks industry spends a great deal on the advertising and marketing of their products. In 2013, US drinks companies alone spent \$866 million on advertising sugary drinks and energy drinks.¹⁴⁶ Direct marketing strategies aimed at children and young people include brand appearances on prime-time television programmes, marketing in social media, and mobile marketing. The soft drinks industry is also increasingly targeting its marketing campaigns towards specific ethnic minority groups—US\$83 million was spent in 2014 on marketing sugary drinks and energy drinks on Spanish language television in the USA, a 44% increase since 2010.¹⁴⁶

Although the consumption of sugary drinks is highest in North America, Latin America, Australasia, and western Europe, sales are now falling in many HICs, and instead substantial growth is expected in many low-income and middle-income countries.¹³³ Coca-Cola outlined plans to invest more than \$4 billion in China between 2015 and 2017, and by 2020 they intend to spend \$12 billion on marketing their products across Africa.¹⁴⁰ PepsiCo has set aside \$12 billion for its Indian operations, to take place by 2020.¹⁴⁰ In contrast, WHO’s total budget for 2017 was \$4.4 billion.¹⁴⁷

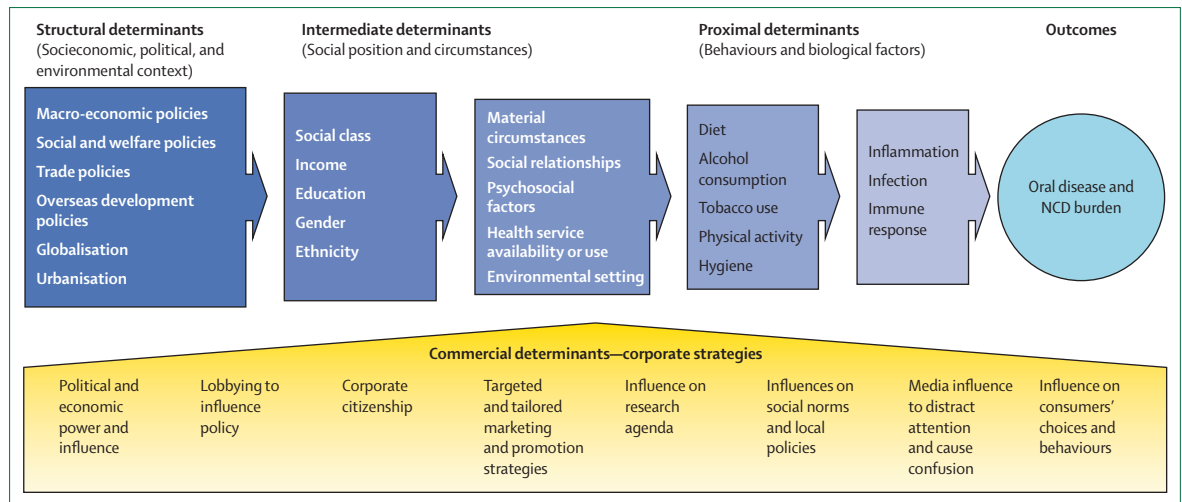


Figure 3: Social and commercial determinants of oral diseases
Adapted from Watt and Sheiham.⁶ NCD=non-communicable disease.

childhood food preferences, purchase requests, consumption patterns, and health. The importance of early years environments to health is now well recognised and tackling how foods are marketed to children is seen as a vital strand in the global strategies for the prevention and control of NCDs. WHO has called on member states to develop appropriate multisectoral approaches to address the marketing of foods and non-alcoholic beverages to children.¹⁵² Individuals might not have full control over their oral health if they have insufficient funds to purchase goods that are beneficial.¹⁵³ For example, fluoride toothpaste has been shown to be much less affordable in countries with lower per capita household expenditure than in countries with higher household expenditure.¹⁵⁴ Another example of how consumer prices can influence oral health is given by the proportion of income needed to purchase sugar-sweetened beverages, which has decreased worldwide since 1990, particularly in LMICs.¹⁵⁵

Knai and colleagues¹⁵⁶ have proposed a systems approach for analysing the commercial determinants of health. Such an approach has the potential to promote an improved understanding of the broader political, institutional, and cultural contexts in which health outcomes, risk factors, and behaviours are embedded. They argue that taking a systems approach to understanding commercial determinants of NCDs will help to more clearly identify how unhealthy commodity industries market their products, gain agency over policy and politics, and legitimise their increasing presence in public health decision making. The involvement of such industries in decision making processes is said to parallel broader shifts in the nature of governments, particularly with many government activities now being devolved to semi-independent organisations.

The adverse influence of corporate players in governmental public health policy more generally is well

documented, with coherence of approaches often apparent across industries.¹⁵⁶ Approaches include criticising health-promotion policies as overbearing governmental interference (a so-called nanny state) and insisting on the importance of consumer choice and individual responsibility. Knai and colleagues¹⁵⁶ suggest that corporations have an effect through being able to create systems that are resilient to public health interventions, having the capacity to adapt and diversify. Buse and colleagues¹³⁶ have expanded on the role of industry in influencing decision making and describe a conceptual framework for governing the commercial drivers of NCD risk. They emphasise the need for the development of new and more robust processes for governance and accountability of NCD prevention at the global level.

Conclusion

Oral diseases are a major global public health problem, having both high prevalence and major negative impacts on individuals, communities, and society. Globally, over 3·5 billion people have oral diseases that are chronic and progressive in nature, starting in early childhood and progressing throughout adolescence and adulthood and into later life. Oral diseases disproportionately affect poorer and marginalised groups in society, being very closely linked to socioeconomic status and broader social and commercial determinants. Increasing consumption of free sugars particularly in LMICs is causing an increase in dental caries, as well as other NCDs such as obesity and diabetes. Dental treatment alone cannot solve this problem. A radically different approach is now needed to tackle this global health challenge.¹⁰

Contributors

All authors jointly formulated the major concepts of this paper and approved the final version. MAP, RGW, LMDM, RJW, and SL initially drafted and edited sections of this paper. MRM and RKC analysed and

generated the 2017 Global Burden of Disease map in figure 1 and the appendix figure on global sugar production. CCG-H and BD generated the figure 2 graph on social gradients in oral health, and RV adapted the social and commercial determinants framework from Watt and Sheiham.⁶ CK, HB, and PA made critical revisions for important scientific content. RGW assumes full responsibility.

Declaration of interests

CK reports a grant from the Laura and John Arnold Foundation, unrelated to this paper. All other authors declare no competing interests.

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