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, 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 essential human daily functions.

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 and health inequalities are directly linked. Oral conditions disproportionally affect poorer and marginalised groups in society, being closely linked to socioeconomic status and the broader social determinants of health. 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, 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 (LMICs), linked to wider social, economic, and commercial changes.

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.

Oral diseases and oral health inequalities are directly influenced by deeper social and commercial determinants, which are the underlying drivers of poor population oral health. 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, periodontal disease, and oral cancers. Despite being largely preventable, oral diseases are highly prevalent, 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 (LMICs), linked to wider social, economic, and commercial changes.

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.

**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, periodontal disease, and oral cancers.
- Despite being largely preventable, oral diseases are highly prevalent, 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 (LMICs), linked to wider social, economic, and commercial changes.
- 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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However, oral diseases are a neglected issue, rarely seen as a priority in health policy. 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.

In this first paper of a two-part Series on oral health, 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 the social, power, or other determinants of health operating in the actual or potential context in which an individual or population lives, determine the health risk or protective factors to which an individual or population is exposed” (World Health Organization’s definition of health determinants).

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 (defined as monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, and sugars naturally present in honeys, syrups, fruit juices, and fruit juice concentrates). 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. 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 lower case letters representing primary dentition and capital letters representing permanent dentition). 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. 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. Tobacco use is also an important independent risk factor for periodontal disease. The sharing of a common inflammatory pathway, periodontal disease is associated with other chronic diseases including diabetes, cardiovascular diseases, and dementia.

In older adults, periodontal disease has been causally linked with aspiration pneumonia, which often results in serious morbidity and mortality. 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). 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. 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. 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.

**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). 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.

**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.

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. In 2010, untreated caries in deciduous teeth was the tenth most prevalent health condition, affecting 9.0% of the global population; the global age-standardised prevalence remained unchanged between 1990 and 2010 (9.0%), 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. 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.

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. These and other data on disease burden came from 186 studies enrolling a total of 3,263,546 individuals aged 5 years or older in 67 countries. Before 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 peaked 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. 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

![Figure 1: Estimated global prevalence of untreated dental caries in permanent teeth for 2017](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 2010.38

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 2010.39

Oral cancer
Lip and oral cavity cancers are among the top 15 most common cancers worldwide, with 500 550 incident cases in 2018.39 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.40 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).41

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.42

A 2015 systematic review assessed the association between socioeconomic position and caries experience in 155 studies involving a total of 329 798 participants.43 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.44 In an update to this review, Costa and colleagues45 identified associations between low 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 Norlund46 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.47

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.48 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.49 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.50 At age 24 years, the study findings revealed that poverty experienced in early life was associated with unsound teeth.51 In Sweden, most socioeconomic inequalities in self-reported dental health were already present early in life and remained in older age (>85 years).52

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 inequality (figure 2). Homeless people living in HICs have more untreated dental caries, more severe tooth loss, and are more likely to experience toothache than

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Effects of oral diseases on individuals, families, and society

Economic burden of oral diseases

Dental diseases impose a substantial economic burden on society.65 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.21 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).

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.75-78 Numerous studies show that untreated dental caries and associated oral problems substantially decrease quality of life for the child and their caregivers.79-84

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.79 Globally, few data exist that document the use of general anaesthesia to treat dental diseases. Schroth and colleagues67 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).85
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. Population-based studies found the 4-week prevalence of all cause orofacial pain to be 26% in the UK100 and 53% in Canada.101 A 2012 report from Brazil estimated that nearly 25% of the adult population had experienced dental pain within the previous 6 months.102

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 2009.103 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.104

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.105–108 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.116 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.117

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.118 However, because of restrictions in public funding for adult dental services, treatment costs are a substantial barrier to care.119 Additionally, many dentists are not well trained in providing care for patients with complex medical problems.120 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 loneliness123,124 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 interventionalist 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. Additionally, recognition is growing 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.

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 including sugary drinks. 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. 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. This overall shift represents a potential minefield is shifting behaviours and contributing to the increase in consumer goods, including high-sugar foods and drinks, economies. The increased availability of unhealthy commercial economic power 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 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. We present a conceptual framework combining the social and commercial determinants of oral health to highlight the interacting influences and processes (figure 3).

Advertising to children is extensive and possible via multiple channels, and can have profound effects on 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 acceptance of the producers via activities such as sponsorship of sporting events and health-care initiatives; and finally, through globally extended supply chains. We present a conceptual framework combining the social and commercial determinants of oral health to highlight the interacting influences and processes (figure 3).

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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.\textsuperscript{152} Individuals might not have full control over their oral health if they have insufficient funds to purchase goods that are beneficial.\textsuperscript{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.\textsuperscript{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.\textsuperscript{155}

Knai and colleagues\textsuperscript{156} 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.\textsuperscript{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 colleagues\textsuperscript{156} 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 colleagues\textsuperscript{156} 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.\textsuperscript{156}

**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. MRB 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. CK, HB, and PA made critical revisions for important scientific content. RGW assumes full responsibility.

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