

Trends in the global, regional, and national burden of oral conditions from 1990 to 2021: a systematic analysis for the Global Burden of Disease Study 2021



GBD 2021 Oral Disorders Collaborators*

Summary

Background The WHO Global Oral Health Action Plan has set an overarching global target of achieving a 10% reduction in the prevalence of oral conditions by 2030. Robust and up-to-date information on the global burden of oral conditions is paramount to monitor progress towards this target. The aim of this systematic data analysis was to produce global, WHO region, and country-level estimates of the prevalence of, and disability-adjusted life-years (DALYs) attributed to, untreated caries, severe periodontitis, edentulism, other oral disorders, lip and oral cavity cancer, and orofacial clefts from 1990 to 2021.

Methods This report is based on the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2021. Input data were extracted from epidemiological surveys, population-based registries, and vital statistics. Data were modelled with DisMod-MR 2.1, a Bayesian meta-regression modelling tool, to ensure consistency between prevalence, incidence, remission, and mortality estimates for oral conditions. DALYs were estimated as the aggregation of the years of life lost (YLLs) due to premature mortality and years lived with disability (YLDs). YLDs were calculated by multiplying prevalence estimates, the severity of the oral condition's sequelae (disability weight) and duration of the sequelae. Although all oral conditions lead to YLDs, only lip and oral cavity cancer and orofacial clefts lead to YLLs as well. 95% uncertainty intervals (UIs) were generated for every metric with the 25th and 975th ordered 1000 draw values of the posterior distribution.

Findings The combined global age-standardised prevalence of the main oral conditions (untreated caries, severe periodontitis, edentulism, and other oral disorders) was 45 900 (95% UI 42 300 to 49 800) per 100 000 population in 2021, with 3.69 billion (3.40 to 4.00) people affected globally. Untreated dental caries of permanent teeth and severe periodontitis were the most common oral conditions, with a global age-standardised prevalence of 27 500 (24 000 to 32 000) per 100 000 population and 12 500 (10 500 to 14 500) per 100 000 population, respectively. Edentulism, severe periodontitis, and lip and oral cavity cancer caused the highest burden as demonstrated by their counts of DALYs and age-standardised DALY rates. Existing trends for 1990–2021 reveal relatively small changes (upward or downward) in prevalence and burden. Increasing counts of prevalent cases and DALYs were noted for all oral conditions but untreated caries of deciduous teeth (no percentage change in prevalence or DALYs) and orofacial clefts (–68.3% [–79.3 to –46.5] decrease in DALYs). There were decreases in both age-standardised prevalence and DALY rate for untreated caries of permanent teeth and edentulism, no change in both for untreated caries of deciduous teeth and severe periodontitis, an increase in the prevalence but no change in the DALY rate for lip and oral cavity cancer, and no change in the prevalence but a decrease in the DALY rate for orofacial clefts. By WHO region, the African and Eastern Mediterranean regions showed the largest increases in prevalent cases and DALYs for most oral conditions, while the European region showed the smallest increases or no change. The European region was the only region with decreasing age-standardised prevalence of untreated caries in both deciduous (–9.88%; –12.6 to –6.71) and permanent teeth (–5.94% (–8.38 to –3.62)). The prevalence and DALY rate of severe periodontitis decreased in the African region, while the prevalence and DALY rate of edentulism decreased in the African region, South-East Asia region, and Western Pacific region. Furthermore, DALY rates of lip and oral cavity cancer decreased in the European region and the region of the Americas, while DALY rates of orofacial clefts decreased in all regions.

Interpretation The minor changes in the burden of oral conditions over the past 30 years demonstrate that past and current efforts to control oral conditions have not been successful and that different approaches are needed. Many countries now face the double challenge of controlling the occurrence of new cases of oral conditions and addressing the huge unmet need for oral health care.

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Research in context

Evidence before this study

Past efforts to report on the global oral health status have focused on specific oral diseases, covered limited regions, and used non-comparable population health metrics. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) has provided robust, comparable, and comprehensive data on trends in oral conditions over the past 30 years. Previous analyses of GBD data have shown that there have been no improvements in the burden of untreated caries, severe periodontitis, and edentulism since 1990, and oral conditions are a substantial population health challenge. GBD 2017 informed the 74th World Health Assembly's resolution on oral health that urged member countries to integrate strategies on oral health promotion, prevention, and treatment into overall non-communicable disease policies. Furthermore, GBD 2019 was used to set targets in the WHO Global Oral Health Action Plan (GOHAP) 2023–2030.

Added value of this study

The GBD 2021 report on oral conditions updates and expands GBD 2019 on many fronts. Notably, it increases the list of oral

conditions to include estimates of the burden of lip and oral cavity cancer and orofacial clefts, allowing, for the first time, a comprehensive evaluation of population oral health. It also incorporates newly available data sources to provide comparable estimates globally as well as for WHO regions and for 204 countries and territories from 1990 to 2021. GBD 2021 provides updated data for GOHAP's monitoring framework, particularly in relation to the core and complementary indicators outlined in overarching global target B (reduced oral disease burden) and the strategic objectives and actions related to surveillance of oral conditions (strategic objective 5).

Implications of all the available evidence

The burden of oral conditions has remained largely unchanged and at a high level over the past 30 years. The continuous updating of GBD data on WHO regions and countries will assist stakeholders in monitoring achievements towards the GOHAP global, regional, and national targets. However, without any sizeable and impactful action there will be little change in the burden of oral conditions at a global, regional, and national level.

Introduction

The 74th World Health Assembly's resolution on oral health¹ has paved the way for an unprecedented effort to promote oral health globally. Many international stakeholders such as the *Lancet* Commission on Oral Health^{2,3} and World Dental Federation⁴ support this endeavour. WHO has published a series of policy documents to define the renewed global oral health agenda,^{5–11} culminating with the WHO Global Oral Health Action Plan (GOHAP) 2023–2030.¹² GOHAP was developed through a consultative process with experts, WHO member states, UN organisations, and non-state actors. It outlines 100 specific actions across six strategic objectives for various stakeholders and actors. GOHAP's monitoring framework sets two overarching global targets and nine global targets related to the strategic objectives, including a set of core and complementary indicators to assess implementation progress. WHO works with the Institute for Health Metrics and Evaluation (IHME), which coordinates the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD), to monitor progress towards some of these targets.¹²

Overarching target B sets a relative reduction of 10% for the combined global prevalence of the main oral diseases and conditions over the life course by 2030. The core indicator for this target is the joint age-standardised prevalence of untreated caries, severe periodontitis, edentulism, and other oral disorders (excluding lip and oral cavity cancer and orofacial clefts). GBD 2019 provided baseline data for GOHAP's monitoring framework, with a global prevalence of 45% and 3·5 billion people affected with oral conditions. Baseline data were presented for the entire world, six WHO regions, and 194 member states.^{5–11}

Prevalence varied from 40% for the Western Pacific region to 48% for the Eastern Mediterranean region. Target B also contains complementary indicators for untreated caries, severe periodontitis, edentulism, oral cancer, and orofacial clefts. That said, GBD is not just important for target B, but also relevant to strategic objectives and actions related to surveillance of oral conditions (strategic objective 5).

Regular updates of GBD are the most relevant disease burden data to assess trends in, and current levels of, oral conditions.^{13–15} GBD 2021 for oral conditions was updated and developed beyond GBD 2019 in two ways. First, it now includes estimates of lip and oral cavity cancer and orofacial clefts along with estimates for the main oral conditions. Second, it incorporated more geographical locations and newly available data sources. In that sense, GBD 2021 supersedes previous GBD and other GBD-based reports, which are therefore not directly comparable. The aim of this component of GBD 2021 is to provide updated global trends in prevalence and disability-adjusted life-years (DALYs) for untreated caries, severe periodontitis, edentulism, other oral disorders, lip and oral cavity cancer, and orofacial clefts, and comparable trends by WHO regions and at country levels over the 1990–2021 period.

Methods

Data input

The full GBD methodology, including the data gathering and estimation process as well as estimations of model fit, can be found in the main report by the GBD 2021 Diseases and Injuries Collaborators and its accompanying appendix.¹⁶ For GBD 2021, we updated

For more on the *Lancet* Commission on Oral Health see <https://www.ucl.ac.uk/epidemiology-health-care/research/epidemiology-and-public-health/research/dental-public-health/lancet-commission-oral-health>

the systematic reviews to inform models for untreated caries,¹⁷ severe periodontitis,¹⁸ and edentulism¹⁹ and reviewed the Global Health Data Exchange for oral health surveys and national reports with oral epidemiology data. Data on lip and oral cavity cancer were sought from population-based cancer registries and databases that include multiple registries. Data on

orofacial clefts were mainly obtained from birth defects registries, hospital discharges, insurance claims, vital registration, and published literature. The GBD case definitions were: any tooth with unmistakable coronal cavity at dentin level, or root cavity in cementum that feels soft or leathery to probing (untreated dental caries); any pocket depth of 6 mm or greater or attachment loss

For the Global Health Data Exchange see <https://ghdx.healthdata.org>

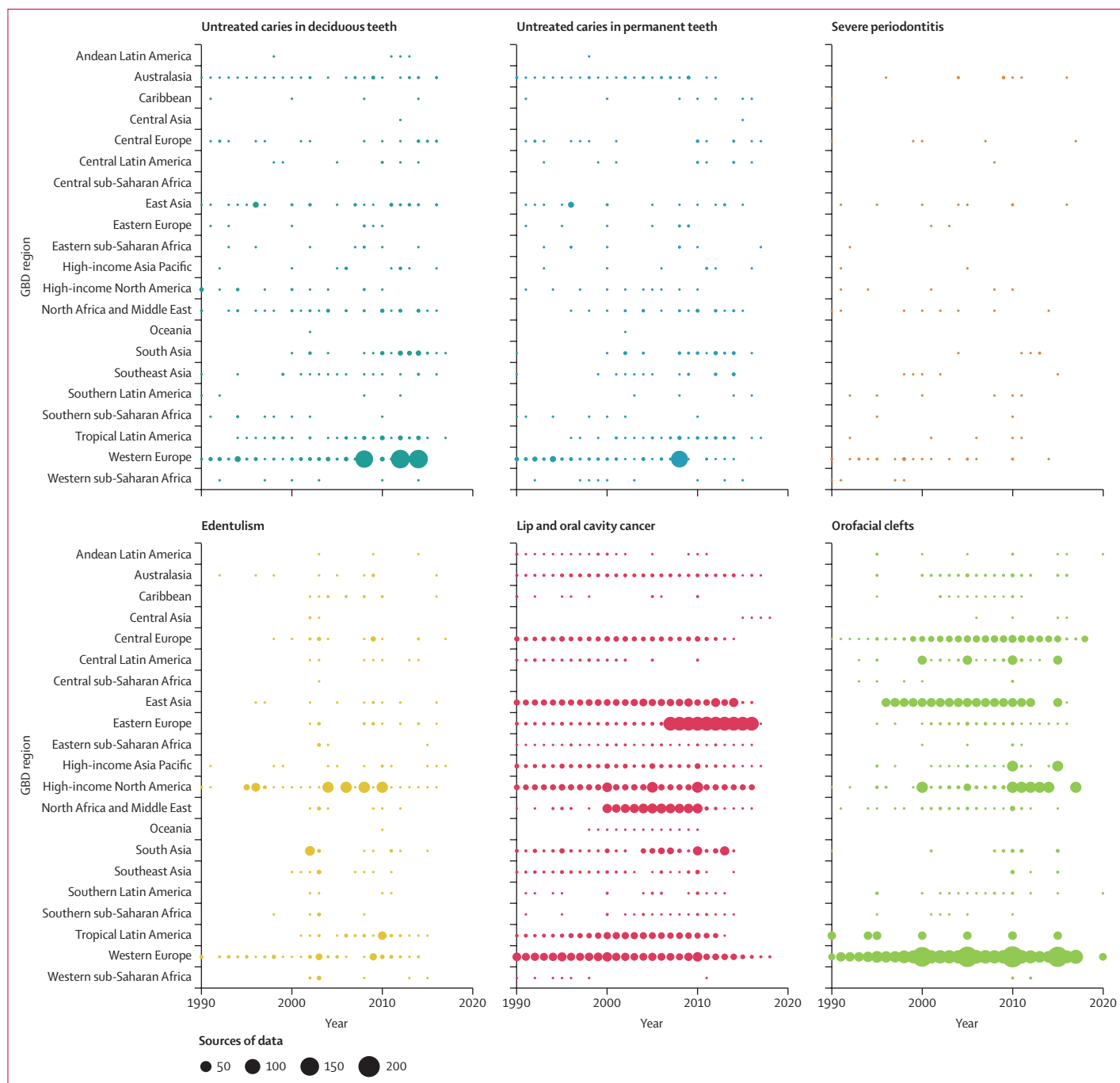


Figure 1: Number of location-years of data availability for oral conditions by GBD region, 1990–2021
GBD=Global Burden of Diseases, Injuries, and Risk Factors Study.

greater than 6 mm (severe periodontitis); no remaining permanent teeth (edentulism); ICD-10 codes C00–C08.9, D10.0–D10.5, and D11–D11.9 (lip and oral cavity cancer); ICD-10 codes Q35–Q37 (orofacial clefts), and other dental, tongue, and jaw disorders and malformations not included in the above case definitions (other oral disorders). The term main oral conditions refers to the combined estimates for untreated caries (deciduous and permanent teeth), severe periodontitis, edentulism, and other oral disorders. Full methodological details are shown in appendix 1. This systematic data analysis adheres to the GATHER statement.²⁰ This manuscript was produced as part of the GBD Collaborator Network and in accordance with the GBD Protocol.

See Online for appendix 1

Data modelling

This report presents the count of prevalent cases and age-standardised prevalence per 100 000 population as well as the count of DALYs and age-standardised DALY

rate per 100 000 population. Age standardisation, based on the GBD reference population, was used to account for variations in both population size and age structure.²¹ To evaluate trends, we present the percentage change in estimates from 1990 to 2021.¹⁵ A trend was considered unchanged if the 95% uncertainty intervals (UIs) for the percentage change crossed zero.

DALYs are the key population metric in GBD, and are estimated as the aggregation of the years of life lost (YLLs) due to premature mortality and years lived with disability (YLDs). Although all oral conditions lead to YLDs, only lip and oral cavity cancer and orofacial clefts lead to YLLs as well. YLDs are calculated by multiplying frequency (prevalence), severity of the condition's sequelae (disability weight), and duration of the sequelae.^{22,23} One DALY reflects a year of healthy life lost due to diseases or injuries, whereas the count of DALYs reflects the gap between the population's current health status and an ideal situation where

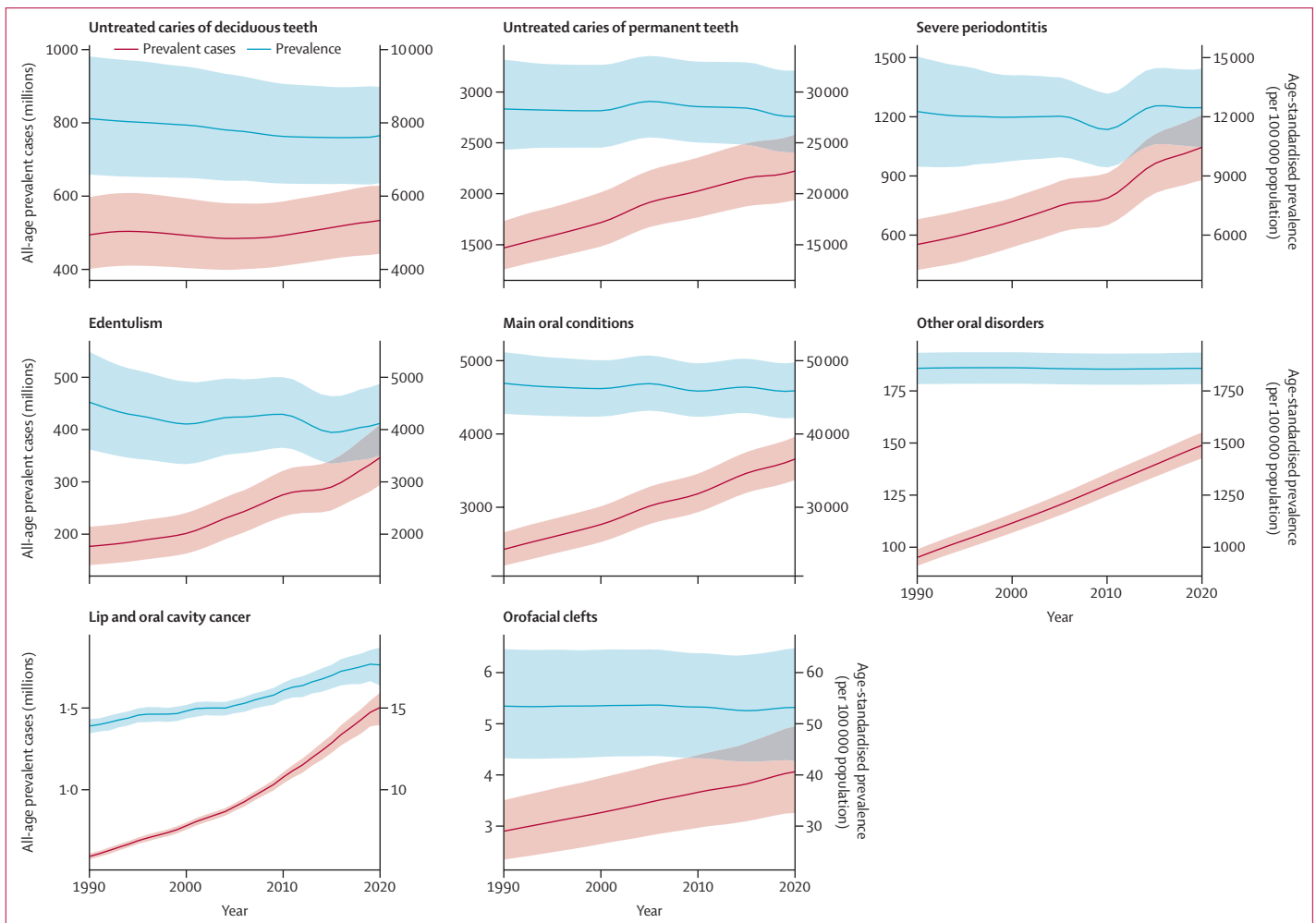


Figure 2: Global trends in counts of prevalent cases and age-standardised prevalence for oral conditions over the period 1990–2021
 Shaded sections indicate 95% uncertainty intervals. Main oral conditions include untreated caries, severe periodontitis, edentulism, and other oral disorders only.

people live the standard life expectancy in full health (disease-free).

Prevalence estimates were modelled with a Bayesian disease meta-regression algorithm (DisMod-MR 2.1), which generates internally consistent estimates of prevalence, incidence, remission, and mortality by sex, location, year, and age group.²⁴ For locations with missing epidemiological data, DisMod-MR 2.1 estimated prevalence across a cascade down the five levels of the GBD geographical hierarchy (ie, world, super-region, region, country, and subnational). In doing so, estimation was informed by epidemiological data from locations higher in the hierarchy, which served as priors for the estimation of disease parameters for locations lower in the hierarchy, and country-level covariates. Uncertainty for every metric was derived from 1000 draws at every step of the computational process. Every metric is therefore reported with 95% UIs based on the 25th and 975th ordered values of 1000 draws of the posterior distribution. Further DisMod-MR 2.1 details, as applied to modelling

oral conditions, are included in appendix 1 (sections 2–7). All data are presented to three significant figures.

Countries were grouped geographically according to the six WHO regional offices (African, region of the Americas, South-East Asia, European, Eastern Mediterranean, and Western Pacific). Some territories, departments, or autonomous zones are not part of any GBD country. These are not included in any country-specific estimates but are counted in the GBD region totals for the region in which that population resides. This is accounted for by region scalars (total region population divided by the sum of country-level populations) in the GBD geographical aggregation cascade. Scalars were applied when going from GBD country to GBD region; thus the sum of prevalent cases or DALYs for the countries within a GBD region might be less than the total prevalent cases or DALYs in that GBD region. No scalars were applied when going from GBD country to WHO region, GBD region to GBD super-region, or GBD super-region to global; thus the sum of prevalent cases or DALYs for the countries within a

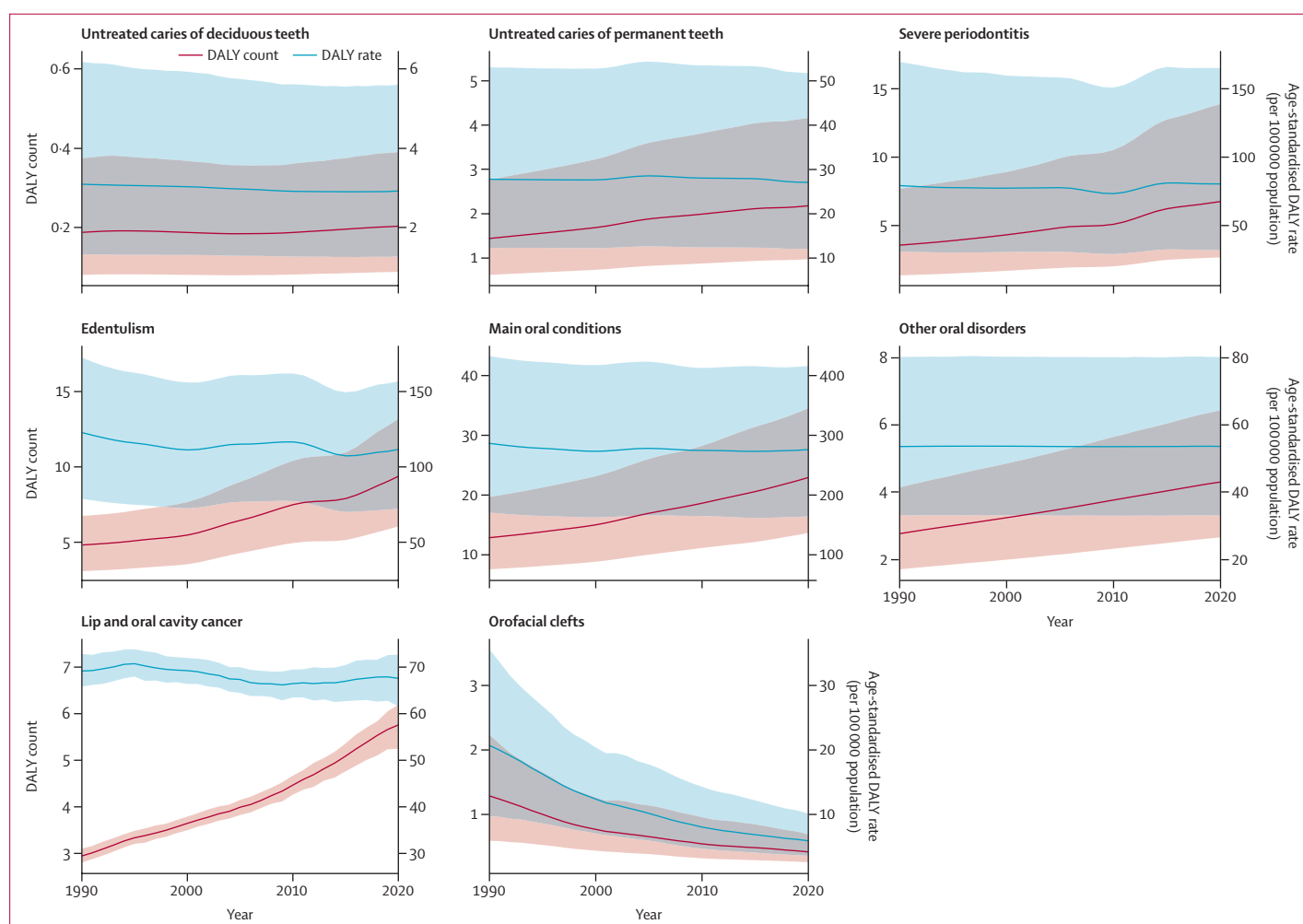


Figure 3: Global trends in counts of DALYs and age-standardised DALY rates for oral conditions over the period 1990–2021

Shaded sections indicate 95% uncertainty intervals. Main oral conditions include untreated caries, severe periodontitis, edentulism, and other oral disorders only. DALY=disability-adjusted life-year.

GBD region equals the total prevalent cases or DALYs in that GBD region.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit the manuscript for publication.

See Online for appendix 2

Results

Data density

Figure 1 shows the data density in terms of data sources by oral condition, GBD region, and year. Data density is higher for oral conditions with administrative data (registries for lip and oral cavity cancer and birth defects registries for orofacial clefts) and certain regions, particularly high-income regions, are more data-dense than others. Figure 1 also highlights how there are fewer data sources from 2015 onwards.

Untreated caries of deciduous teeth

The global counts of prevalent cases and DALYs remained unchanged between 1990 and 2021

(figures 2, 3), with a percentage change in cases of 6·50% (95% UI -1·35 to 16·8; table 1) and a percentage change in DALYs of 6·86% (-3·59 to 20·3; table 2). The age-standardised prevalence and DALY rate also remained unchanged over time. In 2021, the global age-standardised prevalence was 7550 (6290 to 8780) per 100 000 population and the global age-standardised DALY rate was 2·89 (1·27 to 5·54) per 100 000 population. There were no sex differences in global counts and rates (appendix 2 table S2). DALY rates were the highest in children younger than 5 years (appendix 2 table S3).

Increasing trends in prevalent cases and DALYs were observed in the African and Eastern Mediterranean regions, decreasing trends in the European and Western Pacific regions, and no changes in the region of the Americas and the South-East Asia region (tables 3, 4). By 2021, the South-East Asia region had the highest count of prevalent cases and DALYs, whereas the European region had the lowest counts of both. Furthermore, decreasing trends in the age-standardised prevalence (-9·88; -12·6 to -6·71) and DALY rate (-9·71; -16·0 to -2·44) were only observed in the European region.

	Prevalent cases in millions (95% UI)	Percentage change in cases, 1990–2021 (95% UI)	Age-standardised prevalence per 100 000 population (95% UI)	Percentage change in prevalence, 1990–2021 (95% UI)
Untreated caries of deciduous teeth	525 (438 to 611)	6·50% (-1·35 to 16·8)	7550 (6290 to 8780)	-6·88% (-13·9 to 2·32)
Untreated caries of permanent teeth	2240 (1960 to 2600)	53·0% (47·8 to 59·5)	27500 (24 000 to 32 000)	-2·78% (-4·68 to -0·640)
Severe periodontitis	1070 (897 to 1230)	91·5% (57·8 to 137)	12 500 (10 500 to 14 500)	1·76% (-15·6 to 26·6)
Edentulism	353 (301 to 416)	100% (86·8 to 119)	4110 (3500 to 4830)	-9·00% (-15·0 to -0·530)
Other oral disorders	151 (145 to 157)	57·8% (56·3 to 59·4)	1860 (1780 to 1930)	-0·0212% (-0·153 to 0·125)
Main oral conditions	3690 (3400 to 4000)	52·5% (46·4 to 58·5)	45 900 (42 300 to 49 800)	-2·41% (-5·85 to 0·804)
Lip and oral cavity cancer	1·54 (1·44 to 1·63)	162% (141 to 180)	17·7 (16·5 to 18·8)	27·5% (17·4 to 36·0)
Orofacial clefts	4·12 (3·32 to 5·03)	40·4% (33·9 to 46·6)	53·4 (43·0 to 65·0)	-0·104% (-4·75 to 4·18)

Main oral conditions include untreated caries, severe periodontitis, edentulism, and other oral disorders only. Global estimates include 204 countries and territories, of which 195 are WHO member states. Prevalent cases of main oral conditions do not match the sum of prevalent cases of individual conditions because some conditions coexist. All data are presented to three significant figures. UI=uncertainty interval.

Table 1: Global count of prevalent cases, age-standardised prevalence in 2021, and percentage change in count of prevalent cases and age-standardised prevalence over 1990–2021 for oral conditions

	DALYs in thousands (95% UI)	Percentage change in DALYs, 1990–2021 (95% UI)	Age-standardised DALY rate per 100 000 population (95% UI)	Percentage change in DALY rate, 1990–2021 (95% UI)
Untreated caries of deciduous teeth	201 (88·1 to 386)	6·86% (-3·59 to 20·3)	2·89 (1·27 to 5·54)	-6·56% (-16·0 to 5·09)
Untreated caries of permanent teeth	2200 (988 to 4170)	52·3% (47·3 to 59·2)	27·0 (12·1 to 51·4)	-2·72% (-4·65 to -0·545)
Severe periodontitis	6900 (2770 to 14 100)	90·7% (57·2 to 137)	80·9 (32·5 to 165)	1·60% (-15·8 to 26·7)
Edentulism	9590 (6200 to 13 500)	98·9% (86·0 to 118)	112 (72·3 to 157)	-9·08% (-15·1 to -0·735)
Other oral disorders	4350 (2680 to 6510)	57·0% (55·5 to 58·5)	53·6 (33·0 to 80·2)	0·0104% (-0·315 to 0·325)
Main oral conditions	23 200 (13 800 to 35 000)	81·0% (69·3 to 92·3)	276 (164 to 417)	-3·77% (-9·31 to 2·40)
Lip and oral cavity cancer	5870 (5330 to 6350)	100% (75·5 to 119)	67·7 (61·3 to 73·2)	-2·24% (-14·2 to 6·88)
Orofacial clefts	409 (252 to 671)	-68·3% (-79·3 to -46·5)	5·78 (3·48 to 9·82)	-72·2% (-81·4 to -55·0)

Main oral conditions include untreated caries, severe periodontitis, edentulism, and other oral disorders only. Global estimates include 204 countries and territories, of which 195 are WHO member states. DALYs for main oral conditions match the sum of DALYs for individual conditions because they account for comorbidity. All data are presented to three significant figures. DALY=disability-adjusted life-year. UI=uncertainty interval.

Table 2: Global count of DALYs, age-standardised DALY rate in 2021, and percentage change in count of DALYs and age-standardised DALY rate over 1990–2021 for oral conditions

	Prevalent cases in millions (95% UI)	Percentage change in cases 1990–2021 (95% UI)	Age-standardised prevalence per 100 000 population (95% UI)	Percentage change in prevalence 1990–2021 (95% UI)
Untreated caries of deciduous teeth				
African	115 (94.5 to 134)	93.9% (74.5 to 120)	6860 (5630 to 8020)	-6.01% (-15.6 to 7.08)
Eastern Mediterranean	64.2 (53.7 to 75.0)	34.1% (7.44 to 71.5)	7430 (6220 to 8660)	-10.5% (-28.4 to 14.6)
European	40.6 (33.4 to 49.4)	-24.1% (-26.7 to -21.1)	7130 (5850 to 8640)	-9.88% (-12.6 to -6.71)
Region of the Americas	53.9 (43.8 to 64.6)	4.17% (-1.90 to 12.4)	7090 (5790 to 8450)	4.13% (-1.91 to 12.6)
South-East Asia	141 (117 to 165)	-4.81% (-11.6 to 4.36)	8010 (6700 to 9310)	-5.21% (-12.2 to 4.36)
Western Pacific	109 (90.8 to 128)	-16.5% (-19.6 to -13.0)	8350 (6970 to 9810)	-5.55% (-8.95 to -1.63)
Untreated caries of permanent teeth				
African	294 (251 to 345)	128% (124 to 132)	28 700 (24 900 to 33 100)	-4.86% (-6.43 to -3.18)
Eastern Mediterranean	227 (193 to 269)	116% (108 to 125)	31 100 (26 900 to 36 200)	-2.88% (-4.91 to -1.12)
European	337 (299 to 377)	6.84% (3.28 to 10.7)	32 900 (29 000 to 37 600)	-5.94% (-8.38 to -3.62)
Region of the Americas	303 (265 to 348)	53.6% (46.9 to 60.6)	27 900 (24 300 to 32 300)	0.357% (-1.80 to 2.73)
South-East Asia	657 (569 to 765)	73.1% (66.7 to 79.9)	30 700 (26 700 to 35 600)	-5.55% (-7.18 to -3.72)
Western Pacific	418 (358 to 497)	25.1% (14.7 to 40.2)	20 700 (17 600 to 25 000)	-0.124% (-6.43 to 6.80)
Severe periodontitis				
African	93.3 (76.8 to 110)	60.5% (31.5 to 102)	12 000 (9 980 to 14 000)	-33.3% (-44.9 to -17.8)
Eastern Mediterranean	93.1 (75.9 to 110)	177% (115 to 256)	14 200 (11 800 to 16 500)	4.50% (-16.6 to 32.2)
European	129 (103 to 158)	25.7% (-8.12 to 74.4)	10 200 (7 920 to 12 800)	-3.39% (-30.3 to 33.0)
Region of the Americas	144 (121 to 168)	93.3% (60.4 to 141)	12 000 (10 000 to 14 100)	3.02% (-14.9 to 29.0)
South-East Asia	333 (280 to 383)	130% (92.1 to 183)	15 900 (13 400 to 18 100)	7.08% (-9.58 to 31.4)
Western Pacific	268 (223 to 315)	91.5% (61.7 to 132)	10 100 (8320 to 11 900)	-3.72% (-17.8 to 17.0)
Edentulism				
African	19.0 (15.0 to 22.9)	121% (117 to 128)	3080 (2520 to 3650)	-6.85% (-9.09 to -3.69)
Eastern Mediterranean	23.8 (19.4 to 28.6)	148% (137 to 164)	4960 (4140 to 5920)	-4.40% (-8.79 to 2.08)
European	83.1 (70.5 to 97.2)	43.6% (34.3 to 56.8)	5210 (4460 to 6090)	-3.80% (-9.85 to 4.88)
Region of the Americas	79.6 (68.3 to 92.6)	116% (96.7 to 142)	6020 (5160 to 7010)	-0.395% (-9.81 to 11.3)
South-East Asia	54.1 (45.7 to 64.1)	120% (95.8 to 157)	3060 (2620 to 3590)	-15% (-24.1 to -0.761)
Western Pacific	91.7 (74.7 to 111)	139% (126 to 157)	3220 (2640 to 3890)	-10.6% (-14.7 to -4.56)
Other oral disorders				
African	19.3 (18.5 to 20.1)	136% (135 to 137)	1860 (1790 to 1940)	0.143% (0.0607 to 0.213)
Eastern Mediterranean	13.5 (13.0 to 14.1)	120% (118 to 122)	1850 (1780 to 1930)	-0.0125% (-0.0802 to 0.0521)
European	18.9 (18.1 to 19.6)	13.0% (12.1 to 14.0)	1860 (1780 to 1930)	-0.146% (-0.273 to -0.0236)
Region of the Americas	20.1 (19.3 to 21.0)	54.4% (52.7 to 56.1)	1860 (1780 to 1930)	-0.0676% (-0.283 to 0.170)
South-East Asia	39.3 (37.7 to 41.0)	75.5% (73.4 to 77.6)	1860 (1780 to 1940)	0.143% (0.0572 to 0.230)
Western Pacific	39 (37.5 to 40.7)	36.6% (34.1 to 39.3)	1860 (1780 to 1940)	-0.0779% (-0.223 to 0.0968)
Main oral conditions				
African	481 (438 to 528)	111% (101 to 120)	45 200 (41 600 to 49 200)	-10.3% (-14.4 to -6.81)
Eastern Mediterranean	361 (330 to 398)	104% (91.4 to 117)	50 000 (46 100 to 54 200)	-2.54% (-7.50 to 2.06)
European	500 (463 to 537)	9.56% (5.02 to 14.2)	48 800 (44 900 to 52 800)	-5.06% (-8.27 to -1.65)
Region of the Americas	498 (462 to 537)	55.4% (49.5 to 61.9)	46 300 (42 600 to 50 100)	0.832% (-2.32 to 3.98)
South-East Asia	1030 (941 to 1120)	65.4% (58.3 to 72.7)	49 900 (45 800 to 53 800)	-2.54% (-5.76 to 0.651)
Western Pacific	809 (745 to 877)	33.4% (25.7 to 42.6)	39 600 (36 200 to 43 200)	-2.43% (-6.81 to 1.97)
Lip and oral cavity cancer				
African	0.0371 (0.0309 to 0.0440)	196% (149 to 241)	5.88 (4.98 to 6.86)	23.9% (5.74 to 40.1)
Eastern Mediterranean	0.0925 (0.0748 to 0.114)	264% (179 to 386)	15.9 (13.0 to 19.4)	34.0% (4.55 to 78.8)
European	0.344 (0.326 to 0.358)	71.2% (62.9 to 79.3)	23.4 (22.3 to 24.4)	19.3% (13.9 to 24.7)
Region of the Americas	0.261 (0.249 to 0.270)	80.9% (75.5 to 85.9)	19.8 (18.9 to 20.5)	-15.6% (-17.9 to -13.3)
South-East Asia	0.435 (0.378 to 0.486)	266% (205 to 325)	21.8 (19.0 to 24.3)	57.9% (31.4 to 82.8)
Western Pacific	0.334 (0.288 to 0.387)	319% (251 to 390)	12.1 (10.4 to 13.9)	91.8% (62.2 to 124)

(Table 3 continues on next page)

	Prevalent cases in millions (95% UI)	Percentage change in cases 1990–2021 (95% UI)	Age-standardised prevalence per 100 000 population (95% UI)	Percentage change in prevalence 1990–2021 (95% UI)
(Continued from previous page)				
Orofacial clefts				
African	0.603 (0.489 to 0.734)	103% (88.1 to 115)	50.2 (40.3 to 61.5)	-6.8% (-13.1 to -1.31)
Eastern Mediterranean	0.778 (0.618 to 0.952)	108% (91.9 to 124)	102 (81.2 to 125)	7.62% (-0.879 to 15.8)
European	0.314 (0.257 to 0.377)	-4.4% (-9.88 to 1.12)	36.9 (30.2 to 44.1)	-8.35% (-13.6 to -3.18)
Region of the Americas	0.287 (0.231 to 0.348)	31.4% (25.9 to 36.8)	29.3 (23.6 to 35.3)	-2.41% (-6.27 to 1.09)
South-East Asia	1.51 (1.21 to 1.88)	35.9% (27.1 to 44.5)	74.4 (59.5 to 92.4)	-10.0% (-15.8 to -4.75)
Western Pacific	0.613 (0.499 to 0.741)	2.86% (-4.98 to 11.0)	33.7 (27.7 to 40.5)	-13.4% (-19.7 to -7.29)
Main oral conditions include untreated caries, severe periodontitis, edentulism, and other oral disorders only. Estimates include the 195 WHO member states only. Prevalent cases of main oral conditions do not match the sum of prevalent cases of individual conditions because some conditions coexist. All data are presented to three significant figures. UI=uncertainty interval.				
Table 3: WHO region-wise count of prevalent cases and age-standardised prevalence in 2021 and their corresponding percentage change over 1990–2021 for untreated caries, severe periodontitis, edentulism, other oral disorders, main oral conditions combined, lip and oral cavity cancer, and orofacial clefts				

	DALYs in thousands (95% UI)	Percentage change in DALYs, 1990–2021 (95% UI)	Age-standardised DALY rate per 100 000 population (95% UI)	Percentage change in DALY rate, 1990–2021 (95% UI)
Untreated caries in deciduous teeth				
African	43.9 (19.3 to 85.2)	94.9% (72.1 to 127)	2.62 (1.15 to 5.09)	-5.56% (-17.0 to 9.94)
Eastern Mediterranean	24.6 (11.2 to 49.1)	34.6% (1.64 to 77.1)	2.84 (1.30 to 5.66)	-10.2% (-32.2 to 18.3)
European	15.6 (6.57 to 30.6)	-24.0% (-29.6 to -17.6)	2.73 (1.16 to 5.35)	-9.71% (-16.0 to -2.44)
Region of the Americas	20.6 (8.75 to 40.1)	4.41% (-3.89 to 15.3)	2.72 (1.16 to 5.26)	4.38% (-4.0 to 15.5)
South-East Asia	53.8 (23.9 to 103)	-4.31% (-13.4 to 7.18)	3.06 (1.36 to 5.85)	-4.71% (-14.0 to 6.47)
Western Pacific	41.7 (18.1 to 82.2)	-16.3% (-20.8 to -10.7)	3.20 (1.40 to 6.30)	-5.28% (-10.4 to 0.409)
Untreated caries in permanent teeth				
African	290 (125 to 551)	129% (124 to 133)	28.1 (12.6 to 53.0)	-4.63% (-6.35 to -2.93)
Eastern Mediterranean	223 (96.8 to 428)	115% (108 to 124)	30.4 (13.5 to 57.9)	-3.03% (-5.10 to -1.08)
European	328 (149 to 622)	6.30% (2.68 to 10.2)	32.3 (14.5 to 61.3)	-5.91% (-8.31 to -3.55)
Region of the Americas	296 (134 to 564)	52.4% (45.8 to 59.5)	27.3 (12.1 to 52.0)	0.131% (-2.00 to 2.44)
South-East Asia	643 (286 to 1220)	72.6% (66.0 to 79.2)	30.0 (13.4 to 56.7)	-5.30% (-7.01 to -3.43)
Western Pacific	412 (186 to 799)	24.1% (13.7 to 39.4)	20.5 (9.05 to 39.1)	-0.0730% (-6.37 to 7.16)
Severe periodontitis				
African	607 (247 to 1270)	60.4% (31.6 to 103)	77.2 (31.2 to 158)	-33.4% (-44.9 to -17.7)
Eastern Mediterranean	605 (239 to 1240)	176% (115 to 256)	91.7 (36.0 to 186)	4.06% (-17.1 to 31.9)
European	832 (329 to 1710)	24.9% (-8.60 to 74.4)	65.7 (26.1 to 137)	-3.63% (-30.4 to 32.9)
Region of the Americas	929 (375 to 1910)	91.9% (59.0 to 140)	77.5 (31.3 to 160)	2.64% (-15.2 to 28.9)
South-East Asia	2160 (890 to 4310)	130% (91.7 to 183)	103 (42.3 to 204)	7.24% (-9.56 to 31.5)
Western Pacific	1740 (686 to 3490)	89.9% (60.5 to 131)	65.3 (26.0 to 133)	-4.02% (-17.8 to 17.0)
Edentulism				
African	527 (325 to 762)	121% (117 to 128)	84.5 (53.0 to 118)	-6.96% (-9.15 to -3.88)
Eastern Mediterranean	654 (412 to 905)	147% (135 to 164)	135 (86.8 to 187)	-5.00% (-9.39 to 1.70)
European	2250 (1470 to 3150)	43.0% (33.8 to 56.0)	142 (92.5 to 200)	-3.69% (-9.70 to 4.97)
Region of the Americas	2160 (1400 to 3010)	115% (95.5 to 140)	163 (105 to 227)	-0.736% (-10.2 to 10.9)
South-East Asia	1460 (939 to 2080)	119% (94.4 to 155)	82.0 (53.1 to 116)	-14.9% (-24.0 to -0.565)
Western Pacific	2490 (1650 to 3500)	137% (124 to 155)	87.3 (58.0 to 123)	-10.7% (-14.8 to -4.76)
(Table 4 continues on next page)				

By 2021, the Western Pacific region had the highest age-standardised prevalence and DALY rate, whereas the African region had the lowest prevalence and DALY rate. Estimates by country are presented in appendix 2 (table S3).

Untreated caries of permanent teeth

The global count of prevalent cases increased by 53.0% (95% UI 47.8 to 59.5) and that of DALYs increased by 52.3% (47.3 to 59.2), between 1990 and 2021

	DALYs in thousands (95% UI)	Percentage change in DALYs, 1990–2021 (95% UI)	Age-standardised DALY rate per 100 000 population (95% UI)	Percentage change in DALY rate, 1990–2021 (95% UI)
(Continued from previous page)				
Other oral disorders				
African	559 (343 to 832)	137% (135 to 138)	53.5 (33.0 to 80.0)	0.449% (–0.0716 to 1.01)
Eastern Mediterranean	391 (241 to 588)	119% (116 to 123)	53.2 (32.8 to 79.9)	–0.142% (–0.982 to 0.772)
European	540 (334 to 804)	12.4% (11.4 to 13.5)	53.6 (33.0 to 79.9)	–0.0841% (–0.675 to 0.492)
Region of the Americas	576 (357 to 863)	53.0% (51.3 to 54.9)	53.4 (33.0 to 80.0)	–0.276% (–0.819 to 0.216)
South-East Asia	1130 (700 to 1690)	74.9% (72.4 to 77.2)	53.5 (33.1 to 79.8)	0.40% (–0.242 to 0.987)
Western Pacific	1130 (694 to 1690)	35.4% (32.7 to 38.2)	54 (33.1 to 80.8)	0.0531% (–0.566 to 0.709)
Main oral conditions				
African	2030 (1170 to 3210)	102% (83.5 to 120)	246 (142 to 383)	–15.9% (–23.6 to –8.86)
Eastern Mediterranean	1900 (1100 to 2970)	142% (123 to 162)	313 (185 to 475)	–1.53% (–8.24 to 5.73)
European	3970 (2470 to 5850)	30.1% (20.0 to 39.5)	297 (181 to 445)	–3.35% (–10.8 to 4.11)
Region of the Americas	3980 (2450 to 5910)	91.4% (79.9 to 104)	324 (200 to 482)	0.241% (–6.25 to 7.06)
South-East Asia	5450 (3070 to 8750)	103% (88.2 to 120)	271 (155 to 429)	–3.22% (–10.4 to 4.66)
Western Pacific	5810 (3510 to 8700)	82.6% (70.4 to 95.1)	230 (138 to 348)	–5.50% (–9.99 to –0.349)
Lip and oral cavity cancer				
African	287 (238 to 339)	135% (92.0 to 172)	47.3 (39.9 to 55.2)	–1.40% (–17.7 to 12.9)
Eastern Mediterranean	696 (558 to 870)	176% (109 to 278)	124 (101 to 154)	1.97% (–21.7 to 38.5)
European	798 (760 to 835)	10.6% (5.64 to 16.0)	54.7 (52.1 to 57.2)	–22.6% (–26.2 to –18.8)
Region of the Americas	499 (472 to 519)	58.0% (52.5 to 63.7)	38.2 (36.2 to 39.7)	–26.3% (–29.0 to –23.7)
South-East Asia	2610 (2230 to 2920)	142% (97.6 to 183)	133 (115 to 149)	2.70% (–15.9 to 20.1)
Western Pacific	912 (768 to 1070)	113% (72.1 to 160)	32.8 (27.7 to 38.5)	–4.55% (–22.7 to 15.9)
Orofacial clefts				
African	101 (42.4 to 303)	–1.67% (–44.5 to 82.2)	6.66 (3.13 to 18.0)	–42.1% (–67.1 to –4.19)
Eastern Mediterranean	82.1 (48.0 to 146)	–38.6% (–60.8 to 3.02)	10.4 (6.18 to 18.3)	–55.8% (–70.8 to –29.6)
European	22.1 (14.6 to 32.9)	–71.6% (–83.5 to –47.6)	2.83 (1.92 to 4.13)	–76.0% (–86.0 to –52.9)
Region of the Americas	25.3 (18.1 to 36.2)	–65.8% (–74.4 to –52.5)	2.9 (2.09 to 4.02)	–70.3% (–77.2 to –60.0)
South-East Asia	118 (74.8 to 180)	–59.7% (–80.8 to –17.0)	6.2 (3.86 to 9.82)	–64.7% (–82.0 to –35.5)
Western Pacific	59.1 (41.6 to 82.9)	–90.3% (–94.6 to –78.6)	4.47 (2.99 to 6.33)	–89.2% (–93.6 to –77.8)
Main oral conditions include untreated caries, severe periodontitis, edentulism, and other oral disorders only. Estimates include the 195 WHO member states only. DALYs for main oral conditions match the sum of DALYs for individual conditions because they account for comorbidity. All data are presented to three significant figures. DALY=disability-adjusted life-year. UI=uncertainty interval.				
Table 4: WHO region-wise count of DALYs and age-standardised DALY rates in 2021 and their corresponding percentage change over 1990–2021 for untreated caries, severe periodontitis, edentulism, other oral disorders, main oral conditions combined, lip and oral cavity cancer, and orofacial clefts				

(tables 1, 2; figures 2, 3). However, the age-standardised prevalence decreased by –2.78% (–4.68 to –0.640) and the age-standardised DALY rate decreased by –2.72% (–4.65 to –0.545). In 2021, the global age-standardised prevalence was 27 500 (24 000 to 32 000) per 100 000 population and the age-standardised DALY rate was 27.0 (12.1 to 51.4) per 100 000 population (tables 1, 2). No differences in global counts and rates were found between sexes (appendix 2 table S2). DALY rates were the highest in individuals aged 20–29 years (appendix 2 table S3).

Increasing trends in prevalent cases and DALYs were observed in all regions, with the African region having the largest percentage change in prevalent cases and DALYs and the European region having the smallest percentage change in prevalent cases and DALYs (tables 3, 4). By 2021, the South-East Asia region had the

highest counts of prevalent cases and DALYs and the Eastern Mediterranean region had the lowest counts of both. Moreover, decreasing trends in age-standardised prevalence and DALY rate were observed in all regions except for the region of the Americas and the Western Pacific region. By 2021, the European region had the highest age-standardised prevalence and DALY rate, whereas the Western Pacific region had the lowest age-standardised prevalence and DALY rate. Estimates by country are presented in appendix 2 (table S4).

Severe periodontitis

The global count of prevalent cases increased by 91.5% (95% UI 57.8–137) and that of DALYs increased by 90.7% (57.2–137), from 1990 to 2021 (tables 1, 2; figures 2, 3). However, the global age-standardised prevalence and DALY rate remained unchanged. In 2021, the global

age-standardised prevalence was 12 500 (10 500–14 500) per 100 000 population and the global age-standardised DALY rate was 80.9 (32.5–165) per 100 000 population. No differences in counts and rates were found between sexes (appendix 2 table S2). DALY rates were the highest in individuals aged 45–64 years (appendix 2 table S3).

Increasing trends in the count of prevalent cases and DALYs were observed in all regions except for the European region (25.7% [95% UI –8.12 to 74.4] for prevalent cases and 24.9% [–8.60 to 74.4], for DALYs; tables 3, 4). The Eastern Mediterranean region had the largest percentage change in prevalent cases (177%; 115 to 256) and DALYs (176%; 115 to 256). By 2021, the South-East Asia region had the highest counts of prevalent cases and DALYs, whereas the Eastern Mediterranean region had lowest counts of both. Trends in the age-standardised prevalence and DALY rate were unchanged for all regions but decreased in the African region. By 2021, the South-East Asia region had the highest age-standardised prevalence and DALY rates, whereas the Western Pacific region had the lowest. Estimates by country are presented in appendix 2 (table S5).

Edentulism

Between 1990 and 2021, the global count of prevalent cases increased by 100% (95% UI 86.8 to 119) and that of DALYs increased by 98.9% (86.0 to 118), whereas the global age-standardised prevalence decreased (–9.00% [–15.0 to 0.530] and the global age-standardised DALY rate decreased by –9.08% [–15.1 to 0.735]; tables 1, 2; figures 2, 3). In 2021, the global age-standardised prevalence was 4110 (3500 to 4830) per 100 000 population and the global age-standardised DALY rate was 112 (72.3 to 157) per 100 000 population. Global counts and rates were higher in women than in men (appendix 2 table S2). DALY rates were the highest in people aged 70 years and older (appendix 2 table S3).

Increasing trends in the counts of prevalent cases and DALYs were observed in all regions, with the Eastern Mediterranean region having the largest percentage change in prevalent cases and DALYs, and the European region having the smallest percentage change in prevalent cases and DALYs (tables 3, 4). By 2021, the Western Pacific region had the largest counts of prevalent cases and DALYs, whereas the African region had the smallest counts of both. Decreasing trends in the age-standardised prevalence and DALY rate were observed in the South-East Asia, Western Pacific, and African regions. By 2021, the region of the Americas and the European region had the highest age-standardised prevalence and DALY rate, whereas the South-East Asia and African regions had the lowest. Estimates by country are shown in appendix 2 (table S6).

Other oral disorders

Between 1990 and 2021, the global count of prevalent cases increased by 57.8% (95% UI 56.3–59.4) and that of DALYs increased by 57.0% (55.5–58.5), whereas the

global age-standardised prevalence and DALY rate remained unchanged (tables 1, 2; figures 2, 3). In 2021, the global age-standardised prevalence was 1860 (1780–1930) per 100 000 population and the global age-standardised DALY rate was 53.6 (33.0–80.2) per 100 000 population. Globally, there were no differences in DALYs and DALY rates between sexes, but prevalence was higher in women than in men (appendix 2 table S2). DALY rates were the highest in individuals aged 40–54 years (appendix 2 table S3).

Increasing trends in the counts of prevalent cases and DALYs were observed in all regions, with the African region having the largest percentage change in prevalent cases and DALYs, while the European region had the smallest percentage change in prevalent cases and DALYs (tables 3, 4). By 2021, the Western Pacific and South-East Asia regions had the largest counts of prevalent cases and DALYs, whereas the Eastern Mediterranean region had the smallest counts of both. Trends in the age-standardised prevalence and DALY rate were unchanged in all regions. In 2021, the age-standardised prevalence and DALY rate was similar across all regions. Estimates by country are presented in appendix 2 (table S7).

Main oral conditions

The global count of prevalent cases for the main oral conditions increased by 52.5% (95% UI 46.4–58.5) and that of DALYs increased by 81.0% (69.3–92.3) from 1990 to 2021 (tables 1, 2; figures 2, 3). However, the age-standardised prevalence and DALY rate remained unchanged in the same period. In 2021, the global age-standardised prevalence was 45 900 (42 300–49 800) per 100 000 population, with 3.69 billion (3.40–4.00) people affected, whereas the age-standardised DALY rate was 276 (164–417) per 100 000 population. No differences in counts or rates were found between sexes (appendix 2 table S2). DALY rates were the highest in people aged 60 years and older (appendix 2 table S3).

Increasing trends in prevalent cases and DALYs were noted in all regions, with the Eastern Mediterranean region having the largest percentage changes in prevalent cases and DALYs, and the European region having the smallest percentage changes in prevalent cases and DALYs (tables 3, 4). By 2021, the South-East Asia and Western Pacific regions had the largest counts of prevalent cases and DALYs, whereas the Eastern Mediterranean region had the smallest counts of both. Decreasing trends in both the age-standardised prevalence (–10.3%; –14.4 to –6.81) and DALY rate (–15.9%; –23.6 to –8.86) were only observed in the African region. By 2021, the Eastern Mediterranean region had the highest age-standardised prevalence and the region of the Americas had the highest age-standardised DALY rate, whereas the Western Pacific region had the lowest age-standardised prevalence and DALY rate. Estimates by country are presented in appendix 2 (table S8).

Lip and oral cavity cancer

The global count of prevalent cases increased by 162% (95% UI 141–180) and that of DALYs increased by 100% (75.5–119) between 1990 and 2021 (tables 1, 2; figures 2, 3). The age-standardised prevalence increased by 27.5% (17.4–36.0), while the age-standardised DALY rate remained unchanged. In 2021, the global age-standardised prevalence was 17.7 (16.5–18.8) per 100 000 population, while the global age-standardised DALY rate was 67.7 (61.3–73.2) per 100 000 population. Global counts and rates were higher in men than in women (appendix 2 table S2). DALY rates were the highest in people aged 50 years and older (appendix 2 table S3).

Increasing trends in prevalent cases and DALYs were observed in all regions, with the largest percentage change in prevalent cases and DALYs found in the Eastern Mediterranean and South-East Asia regions. Three patterns were observed for the trends in the age-standardised prevalence and DALY rate by WHO regions. First, both rates decreased in the region of the Americas. Second, prevalence increased and DALY rates decreased in the European region. Third, prevalence increased but DALY rates remained unchanged in the African, Eastern Mediterranean, South-East Asia, and Western Pacific regions. By 2021, the highest counts of both prevalent cases and DALYs were found in the South-East Asia region while the lowest counts of both were observed in the African region, whereas the highest DALY rate was found in the South-East Asia region and the lowest found in the Western Pacific region. Estimates by country are presented in appendix 2 (tables S9).

Orofacial clefts

Although the global count of prevalent cases increased by 40.4% (95% UI 33.9 to 46.6) from 1990 to 2021, age-standardised prevalence remained unchanged, while the global DALY count (–68.3%; –79.3 to –46.5) and age-standardised DALY rate (–72.2%; –81.4 to –55.0) both decreased within the same period (tables 1, 2; figures 2, 3). In 2021, the global age-standardised prevalence was 53.4 (43.0 to 65.0) per 100 000 population and the global age-standardised DALY rate was 5.78 (3.48 to 9.82) per 100 000 population. Globally, men had higher counts and rates than women (appendix 2 table S2). Those younger than 5 years had the highest DALY rates (appendix 2 table S3).

Between 1990 and 2021, the count of prevalent cases increased in all regions except for the European and Western Pacific regions, whereas DALYs decreased in all but the African and Eastern Mediterranean regions (tables 3, 4). Moreover, the age-standardised prevalence decreased from 1990 to 2021 for all regions but the Eastern Mediterranean region and the region of the Americas. The age-standardised DALY rate decreased in all regions, with the largest decline observed in the Western Pacific region (–89.2%; –93.6 to –77.8). By 2021, the South-East Asia, African, and Eastern

Mediterranean regions had the largest prevalence and DALY counts and age-standardised rates, whereas the European region and the region of the Americas had the lowest. Estimates by country are shown in appendix 2 (table S10).

Discussion

Main findings

The burden of oral conditions has remained largely unchanged and at a high level over the past 30 years. In 2021, the main oral conditions (untreated caries, severe periodontitis, edentulism, and other oral disorders) affected an estimated 3.69 billion people worldwide. Untreated caries of permanent teeth remained the most prevalent condition of the 371 diseases and injuries assessed in GBD 2021, recording 2.24 billion cases worldwide.²¹ Severe periodontitis recorded 1.07 billion cases while edentulism recorded 353 million cases globally. Conversely, edentulism, severe periodontitis, and lip and oral cavity cancer caused the highest global burden, as demonstrated by their counts of DALYs and age-standardised DALY rates. These findings highlight the double challenge of controlling the occurrence of new cases of oral conditions and addressing the huge unmet need for oral health care now faced by an unparalleled proportion of the global population.

Decreases in the rates of oral conditions need to surpass rates of population growth and ageing to stabilise or even decrease the burden on health systems. Although overall changes in prevalence and burden for 1990–2021 were relatively small (either upward or downward), it is important to highlight some trends. The most striking finding was the decline in rates of untreated dental caries and edentulism. However, it is of concern that the reduction observed in the global age-standardised rate of these oral conditions has not balanced the increase in prevalent cases and DALYs driven by expansions in population size and life expectancy over time. An encouraging finding was the decreasing trend in DALYs and DALY rates for orofacial clefts, despite the increasing trends in prevalent cases. The situation for severe periodontitis, with increasing counts and stagnated rates, is as worrying as that for lip and oral cavity cancer, with increasing counts and prevalence and static DALY rates over time.

Another concerning finding is the inequality among WHO regions in controlling rates of oral conditions. Although the counts for untreated caries, severe periodontitis, edentulism, and lip and oral cavity cancer increased across all WHO regions, there were substantial variations. The African and Eastern Mediterranean regions were behind others, because they showed increases in untreated caries of deciduous teeth, whereas other regions showed decreases; no change in orofacial clefts, whereas other regions showed decreases; or because they generally showed larger increases in untreated caries of permanent teeth, severe periodontitis,

edentulism, and lip and oral cavity cancer than other regions. However, the European region fared better than other regions, showing the smallest increases in counts and marked decreases in rates for all oral conditions but severe periodontitis. The large uncertainty around burden estimates for oral conditions limits our ability to identify more subtle differences between WHO regions. Furthermore, these broad global and regional patterns mask the extensive heterogeneity in trends occurring at the national level, reinforcing the need for national assessments and country-specific planning of health-care services.

Implications of the findings

GBD 2021 for oral conditions superseded GBD 2019 by including more data sources, oral conditions, and locations. GBD 2019 provided baseline data for the WHO global oral health status report,⁵ regional summaries,^{6–11} and GOHAP.¹² However, estimates in these WHO policy reports differ from published GBD data because they incorporate UN population estimates instead of the GBD reference population.^{5,25} Globally, there were 3·5 billion people affected by the main oral conditions in 2019 according to GOHAP and 3·69 billion (95% UI 3·40–4·00) according to GBD 2021. Although our findings confirm that both sets of estimates are very similar, we argue that GBD data should be used as published. This will accelerate access to timely and consistent data on oral conditions as new GBD cycles are released.

Another important distinction is that GOHAP baseline data on lip and oral cavity cancer were derived from the International Agency for Research on Cancer's Global Cancer Observatory (GLOBOCAN), not GBD. Key differences between both databases exist, especially in countries without high-quality national or regional population-based cancer registries.²⁶ This is in addition to known differences in case definitions (ICD-10 codes used), geographical coverage, and data modelling.²⁷ It is also worth noting that GOHAP estimates were often presented without 95% UIs (although these are always available). GBD estimates attempt to capture uncertainty from data gathering and modelling with 95% UIs. Such uncertainty will become important when evaluating the reductions targeted in GOHAP.

The findings also highlight the need for regular and detailed reporting of population-based oral health surveys. Despite efforts to identify and include more primary data (105 new sources compared to GBD 2019), it is worrying that only a few were identified in the past 5 years. The shift from disease surveillance to oral health information systems could broaden the breadth of resources available for decision making and has been embraced in GOHAP strategic objective 5 (oral health information systems). Modelling alone cannot provide an accurate representation of reality; primary data are paramount. The strengthening of information systems

must include systematic collection of primary data on oral health status. Up to now, GBD for the main oral conditions has been based on prevalence and incidence studies. Adding routinely collected data (eg, health records and claims data) to the GBD pool is a possibility. Although this approach might increase data density, it will add a new source of uncertainty and is unlikely to add information for locations with few or no primary studies.

Limitations

Most limitations are related to inconsistencies in data availability.²⁸ Some countries, mostly in the African region, the region of the Americas, and the South-East Asia region, had scarce data on oral conditions. Even when data were available, they might not have been obtained with the GBD case definition or measurement method. Furthermore, the reliability of cancer registries and vital registration systems is inconsistent across countries. In each GBD release, there might be existing data that were not identified or included, which highlights the need for ongoing cycles of releases.

Where data are unavailable, estimation relies on statistical modelling and the use of covariates. Although some of this heterogeneity is captured by measuring uncertainty at different stages of the estimation process, it generates large 95% UIs around estimates, particularly in locations with sparse or absent data. Larger 95% UIs make it more difficult to distinguish small differences from no differences between groups, locations, or timepoints. Our analysis attempts to capture uncertainty from a range of data types and processes (eg, from stochastic variation in input data, age-sex splitting, bias corrections, and other data manipulations or statistical approaches), but it is difficult to capture all sources of uncertainty across the entire estimation process.

Future directions

Influencing oral epidemiologists to produce primary data of sufficient quality as well as identifying and including additional unpublished primary studies (ie, survey reports) are key priorities to enlarge the GBD pool of sources. The Guidelines for Reporting Burden Epidemiologic Studies to Inform Burden Estimation (GROESBE) were recently published.²⁹ This is in addition to refining methods for systematic identification of epidemiological studies, data harmonisation, quantification of measurement error, and capturing the corresponding uncertainty within estimates. Collectively, we expect this effort will produce more accurate trends over time for prevalence and burden estimates. Further priorities relate to expanding the list of oral conditions to include noma and adding new locations as well as tracking progress towards existing GOHAP targets and predicting trends under alternative scenarios.³⁰

Conclusion

This systematic data analysis updated the baseline assessment of the global, WHO region, and country-level situation of the burden of oral conditions to monitor progress following the release of WHO GOHAP 2023–2030. The results show that insufficient action over the past three decades has led to little change in population oral health; without future sizeable and impactful action, this trend is likely to continue.

GBD 2021 Oral Disorders Collaborators

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Contributors

Please see appendix 1 (pp 43–44) for more detailed information about individual author contributions to the research, divided into the following categories: managing the overall research enterprise; writing the first draft of the manuscript; primary responsibility for applying analytical methods to produce estimates; primary responsibility for seeking, cataloguing, extracting, or cleaning data; designing or coding figures and tables; providing data or critical feedback on data sources; developing methods or computational machinery; providing critical feedback on methods or results; drafting the manuscript or revising it critically for important intellectual content; and managing the estimation or publications process. The lead, corresponding, and senior authors had full access to all the data in the study and had final responsibility for the decision to submit the manuscript for publication.

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Data sharing

To download the data used in these analyses, please visit the Global Health Data Exchange GBD 2021 website (<http://ghdx.healthdata.org/gbd-2021/sources>).

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