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Original Article

# National and Subnational Burden of Oral Disorders and Lip and Oral Cavity Cancer in Iran: Based on the Global Burden of Disease Study 2021

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**Abstract**

**Background:** Oral disorders are among the major causes of nonfatal disability, whereas lip and oral cavity cancer (LOCC), classified separately under neoplasms in the Global Burden of Disease (GBD) hierarchy, contributes to both fatal and nonfatal burden. We assessed the national and subnational burden of the disorders in Iran from 1990 to 2021.

**Methods:** GBD 2021 estimates were extracted for Iran and its 31 provinces. The analysis included caries of deciduous and permanent teeth, periodontal diseases, edentulism, other oral disorders, and LOCC. Age-standardized incidence, prevalence, mortality, years lived with disability, years of life lost, and disability-adjusted life years (DALYs) were examined. Changes in absolute counts were decomposed into population growth, age-structure change, and rate change. Age–period–cohort models were fitted for LOCC incidence and mortality.

**Results:** The DALY rate for oral disorders was 318.38 per 100,000 in 2021 versus 314.99 in 1990 (+1%), indicating a high but largely stable burden. LOCC incidence increased from 0.61 to 0.94 per 100,000 (+54%), prevalence from 1.69 to 3.48 (+106%), mortality from 0.40 to 0.46 (+14%), and DALYs from 9.63 to 10.79 (+12%). Men had higher DALY rates for LOCC and oral disorders, and both burdens increased with age. Provincial variation was greatest for LOCC. Oral-disorder counts increased mainly because of population growth, whereas LOCC incidence and deaths increased through demographic and rate changes. Age–period–cohort models showed adverse period effects from the 2010s and limited cohort effects.

**Conclusion:** Iran faces two distinct oral-health challenges: A high and persistent disability burden from oral disorders and a smaller but increasing burden from LOCC. Condition-specific prevention, equitable access to essential oral care, tobacco control, early detection, and improved surveillance are required.

**Keywords:** Dental caries, Periodontal diseases, Mouth, Edentulous, Mouth neoplasms, Lip neoplasms

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## Introduction

Oral health is essential for speech, nutrition, and social interaction.[1,2] Oral disorders, including dental caries, periodontal disease, edentulism, and other oral disorders, can impair these functions, cause pain and discomfort, and are associated with systemic conditions including hypertension, diabetes, cardiovascular and respiratory diseases, chronic kidney disease, cancer, and Alzheimer's disease.[1,3] Lip and oral cavity cancer (LOCC) is among the most common head-and-neck malignancies.[4,5] In the GBD cause hierarchy, oral disorders and LOCC are classified as distinct causes: Oral disorders are grouped under other non-communicable diseases, whereas LOCC is classified under neoplasms.[3,6]

In 2021, an estimated 3.69 billion people were affected by oral disorders; the average age-standardized YLD rate was approximately 276 per 100,000 globally, representing about 2.6% of total YLDs.[3] In 2020, LOCC accounted for approximately 377,700 incident cases and 177,800 deaths worldwide.[4] These burdens are inequitably distributed, with a disproportionately higher impact in many low- and middle-income countries.[1,2]

Iran exemplifies this pattern.[7] Nationally representative data from 2017 reported a mean DMFT of 10.8 for permanent dentition (95% UI: 7.5–14.5), and a mean dmft of 5.03 for deciduous dentition (95% UI: 2.82–7.29).[8,9]

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Missing teeth accounted for 52.3% of total DMFT in 2023.[10] The age-standardized prevalence of shallow periodontal pockets was 24.38%, and that of deep pockets was 2.76% in 2017.[11] In 2019, oral health problems in Iran were associated with an estimated USD 1.8 billion in annual productivity losses and USD 3.5 billion in annual oral-health expenditures.[12] The age-standardized incidence rate for oral cavity cancer has been estimated to be 1.96 per 100,000 in men and 1.36 per 100,000 in women.[13] With population aging, increasing life expectancy, and ongoing exposure to risk factors, including smoked and smokeless tobacco, LOCC incidence in Iran is expected to rise.[14-16]

Regularly updated oral disease-burden data are critical for improving health outcomes and guiding policy.[17] These data help identify key challenges, monitor progress toward oral-health objectives, and support efficient resource allocation. Iran is among the few countries that have conducted comprehensive national surveys on oral disease burden as part of the National and Subnational Burden of Diseases, Injuries, and Risk Factors (NASBOD) project and compared these estimates with the GBD findings to assess concordance.[8,9,11] This study used the GBD 2021 estimates to assess the national and subnational burden of the complete GBD-defined oral-disorders cause group—including caries of deciduous teeth, caries of permanent teeth, periodontal diseases, edentulism, and other oral disorders—together with LOCC in Iran from 1990 to 2021, with estimates reported by sex at national and subnational levels.

## Materials & Methods

### *Data Sources*

Data were obtained from the Global Burden of Disease (GBD) project, curated by the Institute for Health Metrics and Evaluation (IHME). GBD 2021 provides estimates of mortality and morbidity for hundreds of diseases and injuries and 88 risk factors across 204 countries and territories.[6,14] We extracted annual estimates for Iran at the national and provincial levels for 1990–2021 using the publicly available GBD Results Tool on the Global Health Data Exchange (GHDx).[6] For each location-year, age-standardized results were retrieved for both sexes combined and separately for males and females, consistent with the IHME guidance. GBD 2021 denotes the estimation round ending in 2021 rather than the year in which the estimates were released.

### *Case Definitions and Cause Mapping*

We analyzed two distinct outcome groups defined in the GBD cause hierarchy: The GBD-defined oral-disorders cause group and lip and oral cavity cancer (LOCC). Oral disorders are classified under other non-communicable diseases and comprise caries of permanent teeth, caries of deciduous teeth, periodontal diseases, edentulism, and other oral disorders. LOCC is classified separately under neoplasms.[3,6] In GBD, LOCC includes all malignant neoplasms arising in the lip or oral cavity, corresponding to ICD-10 codes C00–C06, including cancers of the lip, tongue, gum, floor of mouth, palate, and other parts of the mouth. "Other oral disorders" was retained as the official residual GBD cause label and was not an author-defined aggregation. The study was not intended to encompass all clinical conditions affecting the oral and craniofacial region. Orofacial clefts, noma, and orodental trauma are not included in the GBD oral-disorders cause group and were outside the prespecified scope of this analysis.[5,6] By GBD convention, oral disorders are nonfatal causes and therefore contribute only to YLDs, whereas LOCC contributes to both YLLs and YLDs.[3] All causes and mappings followed the official GBD 2021 cause list and ICD coding.

### *IHME Estimation Framework*

We assessed incidence, prevalence, deaths, YLLs, YLDs, and DALYs for LOCC and oral disorders. Methodological details are described in the GBD 2021 oral-conditions report and IHME documentation.[3,6]

### *Statistical Analysis*

All metrics are presented annually for 1990–2021 as counts and rates. Consistent with GBD standards, rates are expressed per 100,000 population, with incidence reported per 100,000 person-years. We calculated age-standardized rates using the GBD 2021 world standard population via direct standardization and reported them for both sexes combined and separately by sex. Each estimate is presented with a 95% uncertainty interval (UI), following the GBD 2021 methods.[6]

Temporal trends were summarized using percent change (PC) between 1990 and 2021 at the national and provincial levels. Changes in absolute counts were decomposed into population growth, age-structure change, and incidence-rate change using an APCI stepwise decomposition framework, as applied in recent GBD regional analyses.[6,18] We then fitted age–period–cohort (APC) models for LOCC incidence and mortality using the Epi package in R, following Carstensen's spline-based APC approach and recent GBD-aligned applications.[19] Analyses used the GBD 2021 analytical platform and R v4.1.1 for data processing and visualization.

## Results

Unless otherwise specified, values are age-standardized rates per 100,000 population (incidence per 100,000 person-years) for both sexes combined. Percent change (PC) denotes the change from 1990 to 2021. The selected 95% UIs are presented in Table 1; complete sex-specific counts, rates, and uncertainty intervals are provided in Supplementary Table S1.

### *Lip and Oral Cavity Cancer*

In 2021, the age-standardized incidence rate in Iran was 0.94, up from 0.61 in 1990 (PC + 54%). The prevalence rate of lip and oral cavity cancer increased from 1.69 to 3.48 (+ 106%). The death rate increased from 0.40 to 0.46 (+ 14%). The DALY rate increased from 9.63 to 10.79 (+ 12%), driven predominantly by mortality (YLL rate 9.41 → 10.41; + 11%), while the YLD rate increased from 0.22 to

0.38 (Figure 1-2).

### *Oral Disorders*

In 2021, oral disorders had a DALY rate of 318.38 compared with 314.99 in 1990 (PC + 1%). The incidence rate decreased from 56,738.85 in 1990 to 56,296.89 in 2021 (−1%), and the prevalence rate decreased from 50,802.02 to 50,184.34 (Figure 1-2).

### *Oral Disorders (by Condition)*

- Caries of permanent teeth: DALY rate of 30.50 in 2021 vs. 31.37 in 1990 (−3%).
- Caries of deciduous teeth: 3.38 in 2021 vs. 3.39 in 1990 (~0%).
- Periodontal diseases: 80.29 in 2021 vs. 79.55 in 1990 (+1%).
- Edentulism: 150.71 in 2021 vs. 147.21 in 1990 (+2%).
- Other oral disorders: 53.49 in 2021 vs. 53.47 in 1990 (~0%).

### *Age and Sex Patterns*

In 2021, men had higher DALY rates than women for

**Table 1.** Summary of national age-standardized burden estimates for oral disorders and lip and oral cavity cancer in Iran, 1990 and 2021

| Cause/outcome | Measure | 1990 ASR (95% UI) | 2021 ASR (95% UI) | Percent change (95% UI) |
|---|---|---|---|---|
| **GBD-defined oral disorders** | | | | |
| All oral disorders | DALYs | 314.99 (186.59–476.30) | 318.38 (192.94–471.07) | +1% (−11% to +17%) |
| Caries of deciduous teeth | DALYs | 3.39 (1.45–6.63) | 3.38 (1.45–6.54) | 0% (−9% to +9%) |
| Caries of permanent teeth | DALYs | 31.37 (14.11–59.97) | 30.50 (13.70–58.85) | −3% (−5% to −1%) |
| Periodontal diseases | DALYs | 79.55 (31.71–168.27) | 80.29 (32.35–167.97) | +1% (−6% to +12%) |
| Edentulism | DALYs | 147.21 (93.28–206.53) | 150.71 (92.20–210.58) | +2% (−22% to +40%) |
| Other oral disorders | DALYs | 53.47 (33.06–79.85) | 53.49 (33.03–79.83) | 0% (−1% to +1%) |
| **Lip and oral cavity cancer** | | | | |
| Lip and oral cavity cancer | Incidence | 0.61 (0.52–0.70) | 0.94 (0.82–1.06) | +54% (+26% to +86%) |
| | Prevalence | 1.69 (1.44–1.95) | 3.48 (3.07–3.94) | +106% (+66% to +153%) |
| | Deaths | 0.40 (0.35–0.46) | 0.46 (0.41–0.52) | +14% (−5% to +37%) |
| | YLDs | 0.22 (0.15–0.29) | 0.38 (0.26–0.51) | +73% (+41% to +112%) |
| | YLLs | 9.41 (8.15–10.81) | 10.41 (9.26–11.61) | +11% (−10% to +33%) |
| | DALYs | 9.63 (8.33–11.06) | 10.79 (9.64–12.06) | +12% (−8% to +35%) |

Values are age-standardized rates per 100,000 population; incidence is expressed per 100,000 person-years. Values in parentheses are 95% uncertainty intervals (UIs). ASR, age-standardized rate; DALYs, disability-adjusted life years; YLDs, years lived with disability; YLLs, years of life lost.

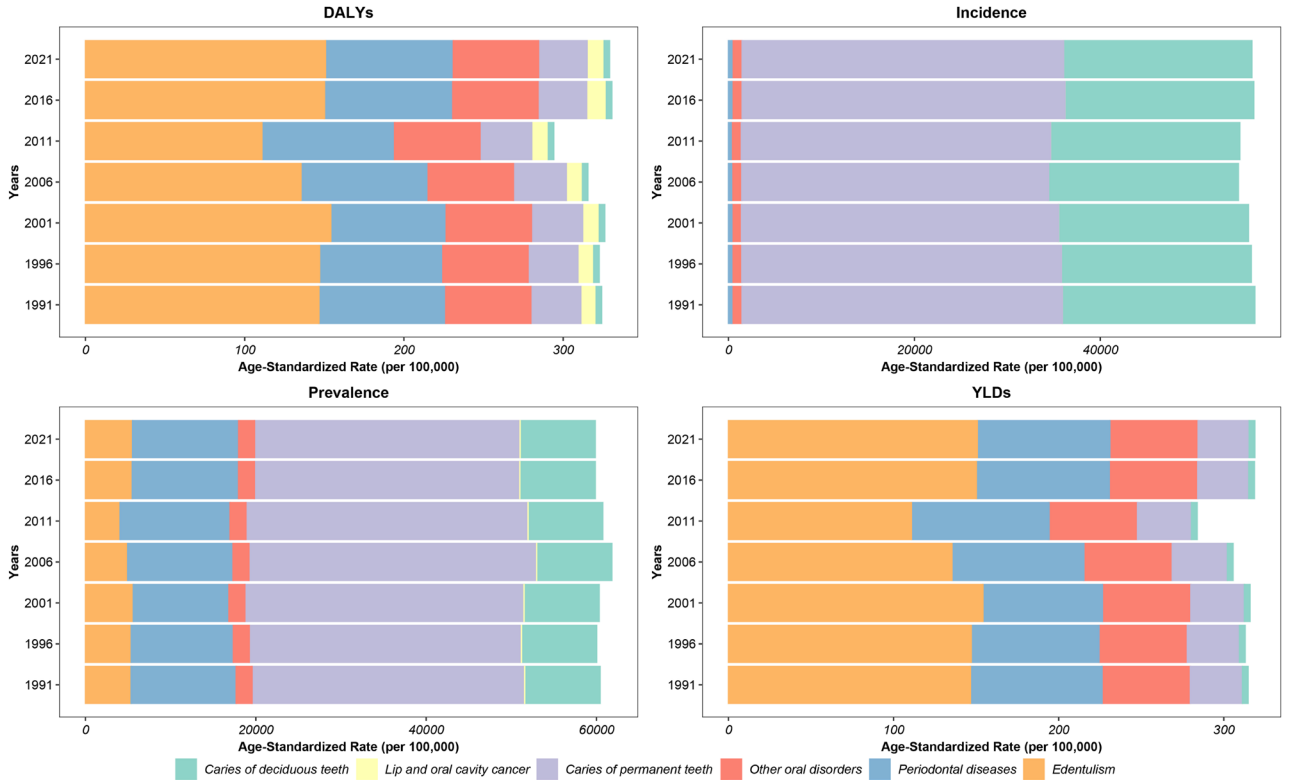



**Figure 1.** Stacked graphs of burden and time trends of incidence, prevalence, death, and disability-adjusted life years

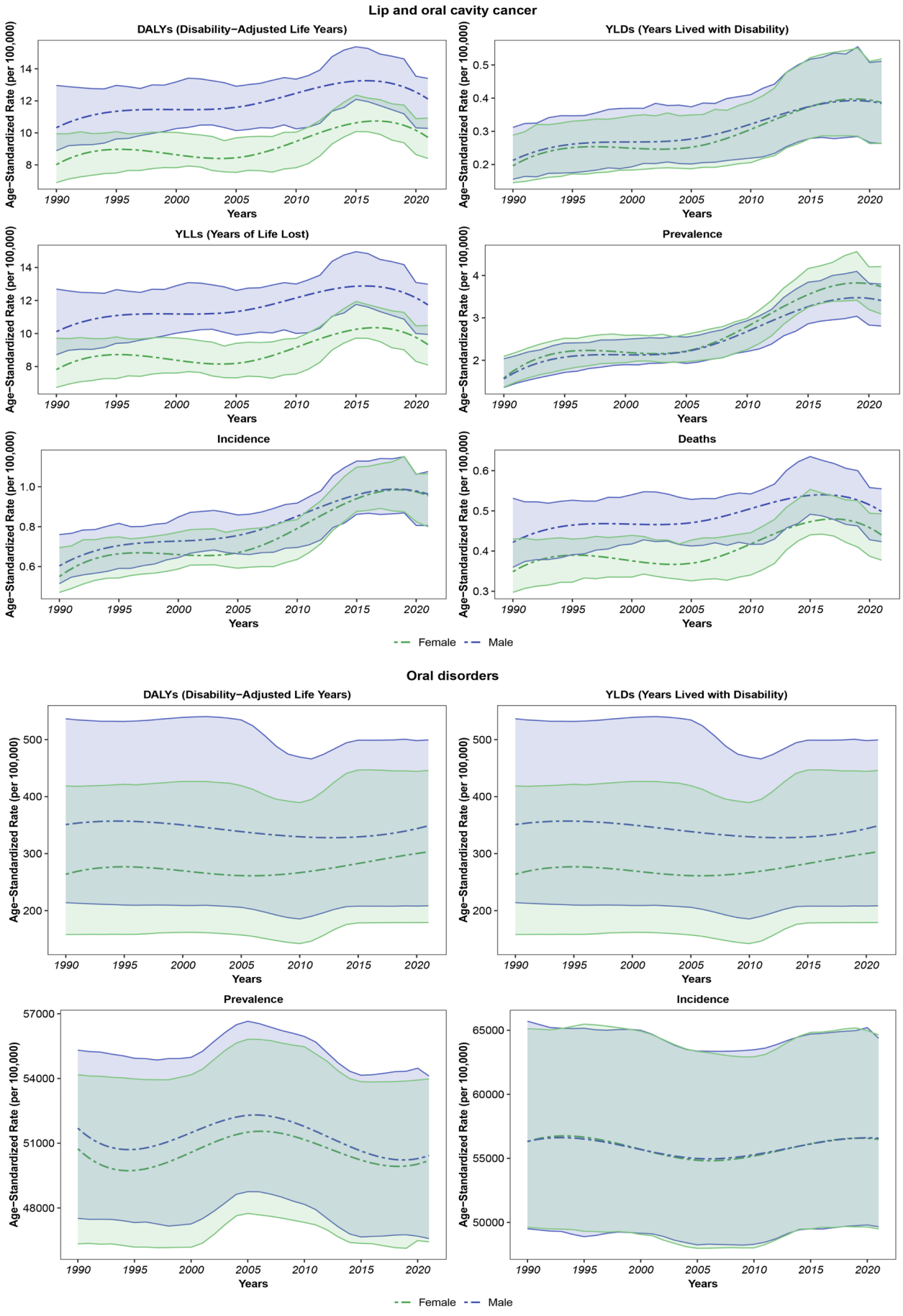



**Figure 2.** Graphs showing trends of different measures of lip and oral cavity cancer and oral disorders from 1990 to 2021 for age-standardized rates

LOCC (11.95 vs. 9.64 per 100,000) and for all oral disorders (340.73 vs. 296.29 per 100,000). By condition, men exceeded women for edentulism and caries of permanent teeth (Appendix), whereas women had slightly higher rates for periodontal diseases and caries of deciduous teeth. The corresponding condition-specific DALY rates (per 100,000) were edentulism (men: 179.67; women: 121.95); periodontal diseases (men: 77.03; women: 83.52); caries of permanent teeth (men: 30.80; women: 30.21); and caries of deciduous teeth (men: 3.36; women: 3.39). LOCC DALY rates increased with age, peaking at ≥ 80 years in males (79 per 100,000) and females (91 per 100,000). The DALY rate for all oral disorders also increased with age, peaking at ≥ 80 years (males 1,403; females 1,060 per 100,000). For caries of deciduous teeth, the highest rate of DALYs was at ages 5–9 years (17 per 100,000). For caries of permanent teeth, male DALYs peaked at 35–44 years (41 per 100,000), while the highest rate of female DALYs was at ages of 20–24 and 40–44 years (both 39 per 100,000). Overall, DALYs for caries of permanent teeth increased from ages 15–19 to 20–24, plateaued at ~37–41 per 100,000 between ages 20–74, and declined thereafter. DALY rates for periodontal diseases increased steadily through adulthood, peaking at 55–59 years in females (216 per 100,000) and 50–54 years in males (199 per 100,000), followed by declines. Edentulism was strongly age-dependent, peaking at ≥ 80 years (males 1,227; females 834 per 100,000). For other oral disorders, the highest DALY rates in 2021 occurred at ages of 45–54 years in females (75 per 100,000) and 45–49 years in males (67 per 100,000).

### *Subnational Results*

In 2021, the highest rate of provincial DALY ASRs for LOCC was reported in Sistan and Baluchestan (25.18) and the lowest rate was in North Khorasan (5.66); changes since 1990 ranged from + 87.37% (Sistan and Baluchestan) to −21.81% (Tehran). For all oral disorders, Tehran had the highest rate (324.15), and Fars showed the lowest rate (308.33), with the largest rise in Isfahan (+ 2.36%) and the largest decline in Ilam (−1.58%). Edentulism peaked in Sistan and Baluchestan (157.20) and its lowest rate was reported in Tehran (147.83); the greatest increase occurred in Zanjan (+ 6.73%) and the greatest decrease was reported in Lorestan (−2.81%). The highest rate of periodontal disease DALYs was in Tehran (87.26), and the lowest rate was in Kerman (71.79); Chaharmahal and Bakhtiari showed the largest increase (+ 7.42%), and Zanjan showed the largest decrease (−8.70%). The highest rate of DALYs for caries of permanent teeth was reported in Sistan and Baluchestan (33.72) and the lowest one in Alborz (25.30); Zanjan had the largest rise (+ 1.03%), and Bushehr had the largest decline (−15.16%). The highest rate of DALYs for caries of deciduous teeth was in Sistan and Baluchestan (3.62) and the lowest one in Gilan (3.02); Golestan had the largest increase (+ 1.77%) and Gilan the largest decrease (−10.66%). For other oral disorders, Lorestan (53.61) ranked the highest and Kerman (53.29) the lowest; Kohgiluyeh and Boyer-Ahmad had the largest increase (+ 0.36%), and Gilan had the largest decrease (−0.25%).

### *Decomposition Analysis*

Total counts for all oral disorders increased by 19.16%, primarily because of population growth (+ 49.48%), partly offset by age-structure change (−29.54%) and a near-zero incidence-rate change (−0.78%). For lip and oral cavity cancer (LOCC), incidence counts increased + 369.70% (components: PG + 49.88%, ASG + 158.21%, IRC + 161.61%), and deaths increased + 266.03% (PG + 48.43%, ASG + 181.17%, IRC + 36.43%). Female component effects exceeded male values for deaths (females: ASG + 197.96%, IRC + 48.03%; males: ASG + 163.43%, IRC + 28.07%). The decomposition analysis for oral disorders is shown in Table 2.

### *Age-Period-Cohort Analysis*

Mortality coefficients increased from −1.56 at ages 15–19 years to + 1.06 at ages 75–79 years (Figure 3), then decreased to + 1.01 at ages + 80 years. Incidence coefficients increased from −1.24 (15-19) to + 0.74 (75-79), then decreased to + 0.59 at ages 80 + years. Most age coefficients were statistically significant at $P < 0.001$; for mortality, ages 45–49 years were not significant (−0.04; $P = 0.5024$).

**Period effects:** Coefficients shifted from negative in the early 1990s to positive by the 2010s: incidence coefficient increased from −0.79 (1991) to + 0.62 (2020); mortality rate increased from −0.61 (1991) to + 0.45 (2020). Mortality period coefficients were statistically significant from 2012 onward; incidence coefficients were significant by 2010, with all years from 2012 to 2021.

**Cohort effects:** Most cohort coefficients did not differ

**Table 2.** Summary of decomposition of changes in absolute counts for oral disorders and lip and oral cavity cancer in Iran, 1990–2021

| Cause | Outcome | Sex | 1990 count | 2021 count | Scenario I | Scenario II | PG (%) | ASG (%) | IRC (%) | TC (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Caries of deciduous teeth | Incidence | Both | 19,366,707 | 14,864,627 | 28,950,245 | 15,244,451 | 49.48% | -70.77% | -1.96% | -23.25% |
| Caries of permanent teeth | Incidence | Both | 19,352,961 | 30,519,542 | 28,929,696 | 30,452,130 | 49.48% | 7.87% | 0.35% | 57.70% |
| Edentulism | Incidence | Both | 113,793 | 328,107 | 170,104 | 322,005 | 49.49% | 133.49% | 5.36% | 188.34% |
| Periodontal diseases | Incidence | Both | 418,029 | 1,059,260 | 624,889 | 1,059,500 | 49.48% | 103.97% | -0.06% | 153.39% |
| Other oral disorders | Incidence | Both | 39,251,490 | 46,771,535 | 58,674,934 | 47,078,088 | 49.48% | -29.54% | -0.78% | 19.16% |
| Lip and oral cavity cancer | Deaths | Both | 92 | 335 | 136 | 302 | 48.43% | 181.17% | 36.43% | 266.03% |
| | Incidence | Both | 156 | 733 | 234 | 481 | 49.88% | 158.21% | 161.61% | 369.70% |

Scenario I represents the expected 2021 count due to population growth alone; Scenario II represents the expected 2021 count after accounting for population growth and age-structure change. PG, population growth; ASG, age-structure change; IRC, incidence-rate change (mortality-rate change for the deaths outcome); TC, total change.

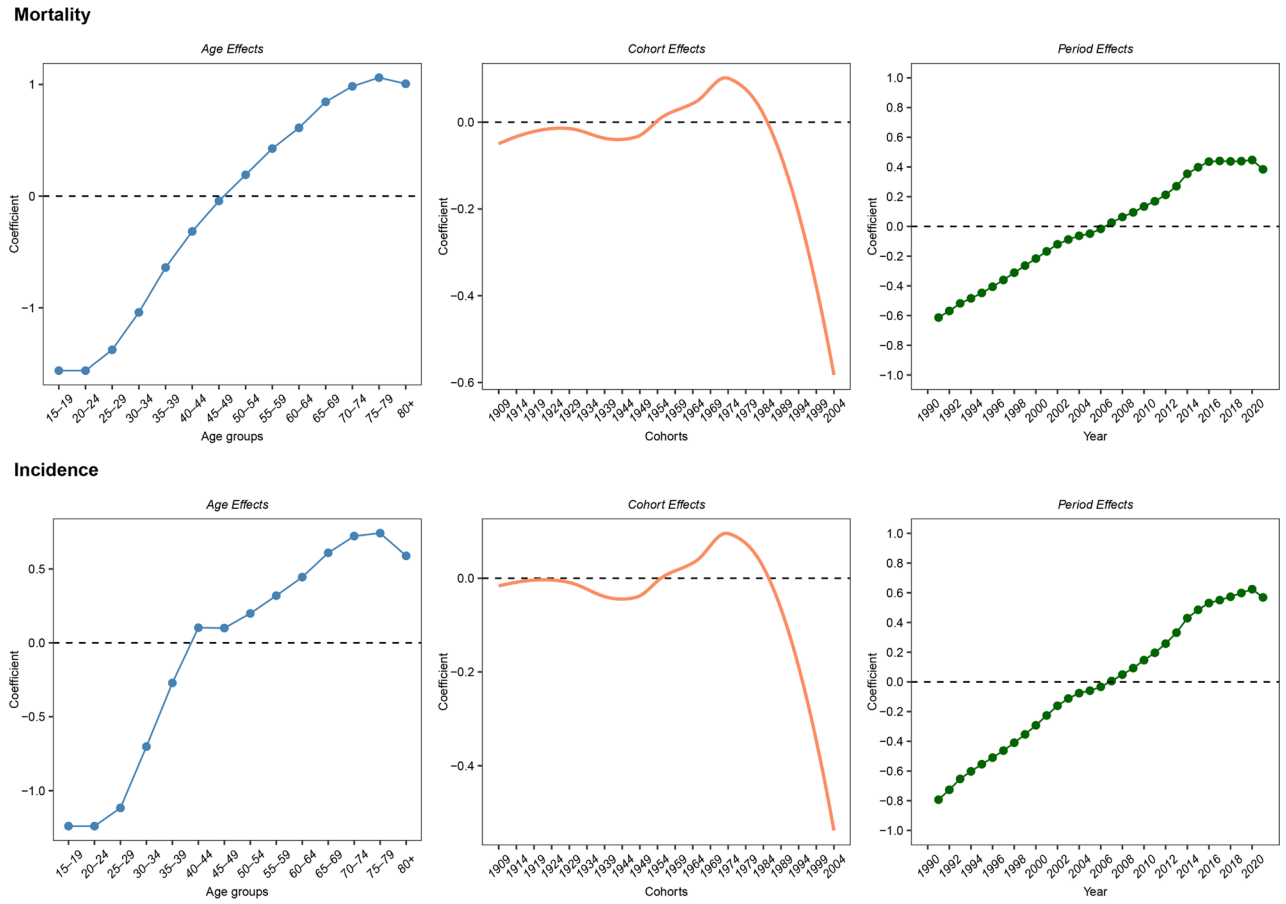



**Figure 3.** Age-period-cohort analysis and graphs of coefficients for each factor

from zero (e.g., 1909 cohort: mortality −0.60, $P = 0.12$; incidence −0.55, $P = 0.08$), indicating limited evidence for cohort-driven variation. These coefficient patterns match the shapes in the APC coefficient plots (age increasing, period turning positive, minimal cohort signal).

## Discussion

This study identified two distinct patterns of oral-health burden in Iran. GBD-defined oral disorders imposed a high but largely stable disability burden between 1990 and 2021, whereas LOCC had a substantially smaller absolute burden but showed increases in incidence, prevalence, mortality, and DALYs. These contrasting patterns provide the rationale for analyzing the two independent GBD cause groups within the same study.

At the national level, the burden of oral disorders has remained broadly stable over three decades. From 1990 to 2021, the DALY rate for all oral disorders changed minimally, from 315 to 318 per 100,000. Periodontal disease increased slightly, from 79.6 to 80.1 per 100,000, and edentulism increased modestly, from 147.2 to 150.2 per 100,000, changes plausibly attributable to population aging. Dental caries was largely stable, with slight improvement: DALYs for caries of permanent teeth decreased marginally, from 31.4 to 30.5 per 100,000, while deciduous caries remained essentially unchanged, from 3.39 to 3.38 per 100,000. Overall, Iran's oral-disorder burden remains high and persistent, reflecting maintenance of the status quo rather than improvement. In 2021, the age-standardized prevalence of oral disorders was approximately 50,184 per 100,000, indicating that nearly one in two Iranians had an active oral disorder.[8,9,11] Nonfatal oral disorders remain widespread and largely unchanged, whereas LOCC has gradually intensified. After three decades of incremental policy changes, Iran has seen no reduction in the burden of oral disorders, underscoring the need for stronger and sustained public-health measures. Although LOCC is far less common than nonfatal oral disorders, it has increased notably. Between 1990 and 2021, LOCC prevalence nearly doubled, from 1.69 to 3.48 per 100,000, and the DALY rate increased moderately, from 9.63 to 10.79 per 100,000 (+12%), driven primarily by premature mortality (YLLs). These trends likely reflect continued exposure to carcinogens, particularly smoked and smokeless tobacco, population aging, and improved case ascertainment.[14-16,20]

GBD 1990–2021 estimates suggest a largely stable oral-health burden in Iran, with minimal change in the DALY rate for all oral disorders, slight increases in periodontal disease and edentulism, and stable to modestly improved caries DALYs. In contrast, national data from Iran for 1990–2017 indicate deterioration in clinical measures. In permanent dentition, the all-ages unadjusted mean number of decayed teeth (DT) increased by approximately 84.5%, and among children with deciduous dentition, decayed teeth increased by more than 17%. Periodontal indicators also worsened: from 1990 to 2017, the age-standardized

prevalence of bleeding on probing (BOP) increased significantly by 73.77%, from 27.11% (95% UI: 22.86%–31.36%) to 47.11% (95% UI: 40.11%–54.12%). Similarly, shallow-pocket prevalence increased by 70.01%, from 14.34% to 24.38%. Conversely, deep-pocket prevalence declined by 69.27%, from 8.98% to 2.76%. Overall, GBD estimates indicate stability or modest increases, whereas national data show increased prevalence of decayed teeth and gingival/periodontal disease.

Methodological and conceptual differences may explain this mismatch and suggest that GBD may understate deterioration.[6] National estimates draw directly on Iranian populations, whereas GBD synthesizes heterogeneous sources using hierarchical models. Sparse or uneven Iranian primary data by province or year may prompt the model to borrow strength from regional covariates, which may smooth over true increases. Policy should therefore prioritize Iranian surveillance data while advocating for better integration of these data into global estimates.

Globally, oral disorders remain a major cause of disability, with an average age-standardized YLD rate of approximately 276 per 100,000 in 2021, largely unchanged since 1990. Iran's corresponding rate was higher, at approximately 318 per 100,000 in 2021, and has not declined. High-SDI regions have seen modest reductions in oral-disorder DALYs, whereas lower-SDI regions have experienced increases. As an upper-middle-income country, Iran's DALY rate has remained above the global average since 1990. Periodontal disease and edentulism in Iran worsened slightly, unlike the declines in severe tooth loss observed in many high-income countries.[1,3] Iran's increase likely reflects rapid population aging and gaps in preventive coverage. LOCC trends are mixed globally: many high-income countries show stable or declining rates, whereas lower-income settings report increases. Iran follows the latter trajectory, with rising LOCC mortality similar to the patterns observed in South and Southeast Asia.[4,5,15]

Marked provincial disparities persist. Sistan and Baluchestan consistently shows the highest burden across multiple indicators. More developed provinces generally show lower total DALYs for oral disorders; however, elevated periodontal DALYs in Tehran, a more developed province in Iran, suggest that development alone is insufficient. These gradients likely reflect socioeconomic disadvantage, service availability, and risk environments, including high smokeless-tobacco prevalence in Sistan and Baluchestan. Inequities in dental-care utilization by income and province further reinforce these disparities.[15,21] However, national data show that the age-standardized DMFT in Sistan and Baluchestan was 8.9 in 2017, among the lowest in Iran.[8] This finding may indicate a discrepancy between GBD estimates and national data.

For all oral disorders, the increase in cases from 1990 to 2021 was driven mainly by demographic change: population growth and aging increased case counts, while incidence rates changed little. Thus, the health system is seeing more oral disease because the population is larger and older, not because individual risk has clearly increased; planning should therefore account for this demographic shift. Unlike nonfatal oral disorders, LOCC showed both demographic and rate-driven increases. Incident cases increased because of population growth, aging, and increasing incidence rates. LOCC deaths also increased with aging and rising mortality rates, suggesting that period risks and/or case ascertainment increased, while survival gains did not fully offset these effects.

Decomposition analysis therefore indicates that the increase in oral-disorder burden mainly reflects demographic change, whereas LOCC reflects both demographic change and rate increases. This pattern supports capacity planning for an aging population, alongside primary prevention and earlier detection of LOCC. Age–period–cohort modeling for LOCC showed age-related increases, positive period effects from the 2010s, and small cohort effects, indicating period-driven rather than cohort-driven change. After adjustment for period and cohort, the age effect increased, with risk rising from midlife and peaking at older ages. The burden is therefore concentrated among older adults. Period effects shifted from negative in the 1990s to positive in the 2010s, independent of age and cohort, consistent with changes in tobacco exposure, detection, coding, or treatment. Cohort effects were small and mostly non-significant, providing limited evidence that cohort-specific exposures drive LOCC trends. Given the dominance of period effects, policy actions should prioritize tobacco control, alcohol-risk reduction, HPV vaccination where applicable, and earlier detection. Given the strong age effect, opportunistic oral cancer screening should focus on older adults, with expedited referral pathways.[14,16]

Advancing toward the WHO Global Oral Health Action Plan (GOHAP) 2023–2030 will require embedding an essential oral-health package within primary care and universal health coverage (UHC), so that access barriers fall and equity improves.[2,17,22] In Iran, where dental care is financed largely through the private sector, with high out-of-pocket spending and limited basic insurance, financial protection should be strengthened by expanding coverage for essential preventive and basic restorative services, introducing targeted subsidies for children and older adults, and prioritizing resources for high-burden provinces. However, financing reforms will not be sufficient if service delivery remains treatment-oriented. Outcomes are unlikely to improve through dentist workforce expansion alone unless care is reoriented toward prevention and early intervention.[12,21]

Mid-level oral-health providers can play a pivotal role in reducing disability and narrowing inequities by providing oral-health education, applying sealants and fluoride varnish, performing scaling and root planing, and using risk-based recall intervals. Evidence-based prevention should be scaled nationwide. School-based sealant programs and fluoride varnish reduce caries and are generally cost-effective;[23] complementary priorities include routine risk-based check-ups, prophylaxis with oral-hygiene instruction, dietary sugar counseling, and

strengthened geriatric oral care within a life-course approach.[24-26] Given the shared risk factors across conditions, integrating oral health into broader NCD strategies, especially comprehensive tobacco control and sugar-reduction policies, could yield synergistic gains. Full adoption and enforcement of the WHO MPOWER-aligned measures remain central to reducing tobacco exposure implicated in LOCC and periodontal outcomes. Finally, robust surveillance is needed to guide resources and track progress.[1,14,16] Regular national oral-health surveys using the WHO-standardized methods, supported by integrated health-information systems, would enable monitoring toward GOHAP targets and timely subnational course correction. Taken together, these actions support a prevention-first, equity-focused agenda aligned with the WHO strategy and calibrated to provincial risk and service landscapes, helping place Iran's oral-health trajectory on track for the 2030 goals.[2,17]

## Conclusion

Using GBD 2021 estimates, Iran experienced two distinct oral-health patterns between 1990 and 2021: A high and largely stable disability burden from GBD-defined oral disorders and a smaller but increasing burden from LOCC. Both burdens were concentrated at older ages, were generally higher among men, and showed substantial provincial variation, particularly for LOCC. The divergence between modeled GBD estimates and some Iranian clinical trends also emphasizes the need to strengthen national surveillance and improve the integration of locally generated data into future burden estimates. Policy responses should be condition-specific. For oral disorders, priorities include integrating an essential oral-health package into universal health coverage, expanding fluoride varnish and sealant programs, reducing sugar exposure, and strengthening preventive, periodontal, and geriatric oral care. For LOCC, priorities include comprehensive tobacco control, risk-based early detection, timely referral, and stronger cancer surveillance. Investment should be prioritized in high-burden provinces, supported by regular WHO-standardized national oral-health monitoring.

### Authors' Contribution

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### Competing Interests

The authors declare that they have no competing interests.

### Data Availability Statement

The data used in this study are publicly available from the Global Burden of Disease Study 2021 through the Global Health Data Exchange (GHDx) and the IHME GBD Results Tool. No new primary data were generated.

### Ethical Approval

This study used publicly available, aggregated, de-identified GBD data and involved no human participants, animal subjects, interventions, or identifiable personal data. Ethics approval was therefore not applicable.

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### Supplementary Files

Detailed epidemiological estimates, decomposition analysis, and age–period–cohort model coefficients, Iran, 1990–2021

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