

# Epidemiology of dental diseases

Measures of frequency, oral health indices, WHO survey methods, global burden and risk factors

**Practical Class 9 · Dental Public Health · 2026/2027**

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## What you will be able to do after this class

1. Link the measures of frequency from Class 8 to dental indices.
2. Calculate and interpret **DMFT/dmft**, **SiC**, the Care Index, **CPI**, **PI/GI**, **OHI-S** and Dean's **Community Fluorosis Index**.
3. Explain why WHO uses **index ages** and a pathfinder sample.
4. Describe the global burden of oral diseases and Bulgaria's position.
5. Link sugars, fluoride, tobacco and HPV to specific diseases and measures.

### Plan of the class (90 min)

0. Recap — 4 min
1. Oral health indices — 36 min
2. WHO survey methods — 8 min
3. Burden: the world and Bulgaria — 12 min
4. Risk factors and the social gradient — 13 min
5. Problems to solve — 15 min

## Recap of Class 8: what the indices measure

| Measure              | In dental epidemiology                                                                                                               |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| prevalence           | share with untreated caries ( $D > 0$ ); share of adults with a pocket $\geq 6$ mm. $DMFT > 0 =$ <b>caries-experience</b> prevalence |
| cumulative incidence | share of caries-free children who develop caries within 3 years                                                                      |
| incidence rate       | new carious surfaces per 100 person-years                                                                                            |
| mean index value     | mean DMFT, PI — severity (intensity); for CPI (ordered codes) — distribution of codes                                                |

### Caries experience is cumulative

Once affected, a tooth stays D, M or F. Therefore **mean DMFT** describes the accumulated caries experience on the day of examination (a cross-sectional measure), whereas the **DMFT increment** shows newly accumulated caries experience. It misses some new lesions: recurrent caries on a filled tooth ( $F \rightarrow D$ ) leaves DMFT unchanged.

Every index needs three specifications: **age**, diagnostic **threshold** and examination **protocol**.

## CONTENTS

- 1. Oral health indices**
2. WHO methods for oral health surveys
3. Global burden and Bulgaria
4. Risk factors and the social gradient
5. Problems

# What makes a good index and why we calibrate examiners

An index is a **standardised numerical scale** for a condition in a population. A good index is:

- **valid** — it measures what it claims to measure;
- **reliable** — reproducible between and within examiners;
- **simple and quick** — usable in field conditions;
- **quantitative** — allows means and comparison;
- **sensitive** to change and **acceptable** to those examined.

## Calibration

Before a survey, examiners assess the same subjects and their agreement is expressed as **Cohen's kappa**. Usual threshold:  $\kappa \geq 0.60$ ; for ordered categories — weighted kappa.

## Index $\neq$ diagnosis

Indices describe individuals and populations but do **not replace** the clinical diagnosis and treatment plan.

## DMFT / DMFS and dmft: caries experience

**DMFT** = number of permanent teeth that are **D** (decayed), **M** (missing due to caries), **F** (filled). It measures **caries experience** — past and present.

- **DMFT**: 0–32 (WHO counts third molars); **DMFS**: surfaces — 4 per anterior, 5 per posterior tooth, up to 148.
- **dmft** (primary teeth): 0–20; in 6–7-year-olds missing incisors are not scored as m.
- A tooth is counted **once**: filling + secondary caries = D.
- **Not counted**: sealants, crowns and bridges for non-carious reasons, implants.

### WHO rule for M

Under 30 years: only teeth **extracted because of caries**.

From 30 years: all teeth lost for any reason (codes 4 and 5) — so in adults M is not a pure measure of caries-related tooth loss.

### Limitations

No denominator (teeth at risk) → always by age. D, M and F have **equal weight**. M and F depend on the dentist's decisions. DMFT = 0 does not mean “caries-free” if initial lesions are not recorded.

Klein, Palmer & Knutson, 1938; WHO (2013), pp. 47–48; Burt & Eklund, ch. 14

## Worked example: DMFT, SiC and Care Index in one class

### Data

12 children aged 12. Individual DMFT:

**0, 0, 0, 0, 1, 1, 2, 2, 3, 4, 5, 7**

Group totals: D = 10, M = 1, F = 14.

### SiC (Significant Caries Index)

Mean DMFT of the **third** with the highest caries experience (Bratthall, 2000). Bratthall's proposed goal: SiC < 3 in 12-year-olds by 2015.

| Measure                                        | Calculation         | Result       |
|------------------------------------------------|---------------------|--------------|
| Mean DMFT                                      | 25 / 12             | <b>2.08</b>  |
| Caries-experience prevalence (DMFT > 0)        | 8 / 12              | <b>66.7%</b> |
| DMFT = 0 (at D3 threshold)                     | 4 / 12              | 33.3%        |
| SiC (top 4 children)                           | (7 + 5 + 4 + 3) / 4 | <b>4.75</b>  |
| Care Index $100 \times \Sigma F / \Sigma DMFT$ | 14 / 25             | <b>56%</b>   |
| Untreated share $\Sigma D / \Sigma DMFT$       | 10 / 25             | 40%          |

The mean of 2.08 looks “low” (below the goal of 3), but one third of the class has on average 4.75 affected teeth — caries is **polarised**.

# ICDAS: caries as a process, not a “hole”

| Code | Criterion (visual, after drying)                                                                    |
|------|-----------------------------------------------------------------------------------------------------|
| 0    | sound surface                                                                                       |
| 1    | first visual change in enamel — usually seen after air drying (in fissures sometimes also when wet) |
| 2    | distinct visual change in enamel — visible when wet                                                 |
| 3    | localised enamel breakdown without visible dentine                                                  |
| 4    | underlying dark shadow from dentine, with or without enamel breakdown                               |
| 5    | distinct cavity with visible dentine                                                                |
| 6    | extensive distinct cavity with visible dentine (more than half of the surface)                      |

## D1 and D3 thresholds

**D1** — all stages, including initial enamel lesions.

**D3** — lesions into dentine (cavitation). D1/D3 are **not** ICDAS codes; every study must state which codes it includes.

## Practical consequence

At the D1 threshold, prevalence and DMFT are **higher**. Comparisons between countries and years are valid only with the **same threshold** and protocol.

# Periodontal indices: from CPITN to the modified CPI (WHO, 2013)

## CPITN — Ainamo et al. (1982)

| Code | Finding              | Need (TN)               |
|------|----------------------|-------------------------|
| 0    | healthy periodontium | 0 — none                |
| 1    | bleeding on probing  | I — oral hygiene        |
| 2    | calculus / retention | II — I + scaling        |
| 3    | pocket 4–5 mm        | II                      |
| 4    | pocket $\geq 6$ mm   | III — complex treatment |

6 sextants; the sextant score is the highest; WHO probe with a 0.5 mm ball tip.

## CPI modified — WHO (2013)

- **Bleeding:** all teeth present — 0 absent / 1 present.
- **Pockets** (from age 15): 0 — none; 1 — 4–5 mm; 2 —  $\geq 6$  mm.
- **Loss of attachment** (from age 15, by sextant, index teeth): 0 — 0–3 mm; 1 — 4–5; 2 — 6–8; 3 — 9–11; 4 —  $\geq 12$  mm.

Severe periodontal disease in WHO/GBD estimates: pocket  $\geq 6$  mm, CPI(TN) code 4 or loss of attachment  $> 6$  mm.

Ainamo J et al. Int Dent J. 1982;32:281–291; WHO Oral Health Surveys: Basic Methods, 5th ed. (2013), pp. 47–51

# Hygiene and gingival indices: PI, GI, OHI-S

## Plaque Index (Silness & Loe, 1964)

- 0 — no plaque
  - 1 — thin film, detected only with the probe
  - 2 — moderate, visible to the naked eye
  - 3 — abundant soft matter
- Mean of 4 surfaces on 6 index teeth.

## Gingival Index (Loe & Silness, 1963)

- 0 — normal gingiva
  - 1 — mild inflammation, no bleeding
  - 2 — moderate: redness, oedema, **bleeding on probing**
  - 3 — severe: marked oedema, ulceration, spontaneous bleeding
- 0.1–1.0 mild; 1.1–2.0 moderate; 2.1–3.0 severe gingivitis.

## OHI-S (Greene & Vermillion, 1964)

**DI-S + CI-S** (debris + calculus), each 0–3 on 6 surfaces: buccal of 16, 26; labial of 11, 31; lingual of 36, 46. DI-S =  $\Sigma$  scores / surfaces examined; CI-S likewise.

Range 0–6: **0–1.2** good; **1.3–3.0** fair; **3.1–6.0** poor hygiene.

Silness & Loe. Acta Odontol Scand. 1964;22:121–135. doi:10.3109/00016356408993968 · Loe & Silness. 1963;21:533–551. doi:10.3109/00016356309011240 · Greene & Vermillion. JADA. 1964;68:7–13

## Fluorosis: Dean's index and the Community Fluorosis Index (CFI)

| Category     | Weight | Criterion                                |
|--------------|--------|------------------------------------------|
| normal       | 0      | smooth, glossy, pale creamy-white enamel |
| questionable | 0.5    | a few white flecks                       |
| very mild    | 1      | opaque white areas < 25% of the surface  |
| mild         | 2      | white areas 25–50%                       |
| moderate     | 3      | all surfaces, wear, brown stain          |
| severe       | 4      | hypoplasia, pitting, corroded appearance |

$$CFI = \frac{\sum n_i \times w_i}{N}$$

### Example (100 children)

40 normal, 20 questionable, 20 very mild, 12 mild, 6 moderate, 2 severe:  
 $(0 + 10 + 20 + 24 + 18 + 8) / 100 = \mathbf{0.80}$

A person is scored on the two most affected teeth; if they differ — on the **less affected** one; when in doubt — the lower category. CFI weights are not the WHO codes (0–5). Historical threshold (Dean): CFI 0.4–0.6 borderline; > 0.6 — a public health problem.

Dean HT. JADA. 1934;21:1421–1426. doi:10.14219/jada.archive.1934.0220; Burt & Eklund, ch. 19; WHO (2013), pp. 51–52

## CONTENTS

1. Oral health indices
- 2. WHO methods for oral health surveys**
3. Global burden and Bulgaria
4. Risk factors and the social gradient
5. Problems

# WHO: Oral Health Surveys — Basic Methods, 5th edition (2013)

| Age       | Why it was chosen                                                                                                                    |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------|
| 5 yrs     | caries in primary teeth — changes quickly; school entry                                                                              |
| 12 yrs    | <b>global indicator age</b> : last age easily reached through schools; most permanent teeth except third molars have usually erupted |
| 15 yrs    | permanent teeth exposed for 3–9 years; periodontium in adolescents                                                                   |
| 35–44 yrs | standard adult group: full effect of caries, severe periodontitis, care                                                              |
| 65–74 yrs | life-course perspective; planning for older people                                                                                   |

## Pathfinder survey

**Stratified cluster** sample: subgroups with different disease levels (urban/rural, regions), **25–50 people** per age group at each site. Example: 12 sites  $\times$  25 = 300 people for one age (25 for low disease levels, about 50 for high). Site selection determines generalisability — this is not a national probability sample.

## Standardisation

Single form, codes, WHO probe, training and calibration, repeat examinations.

# From DMFT targets to universal health coverage

## Quantitative goals

- **DMFT**  $\leq 3$  in 12-year-olds by 2000 (FDI/WHO) — reached in many countries already in the 1990s.
- **SiC**  $< 3$  in 12-year-olds by 2015 (Bratthall, 2000) — focuses attention on the most affected third.

## WHO framework 2021–2030

- Resolution **WHA74.5** on oral health (2021).
- **Global strategy** on oral health (decision WHA75(11), 2022).
- **Global oral health action plan 2023–2030** (decision WHA76(9), 2023): oral health in NCD programmes and in the universal health coverage package.

The goal shifts from “mean DMFT below 3” to **equal access to prevention and treatment** for all groups.

## CONTENTS

1. Oral health indices
2. WHO methods for oral health surveys
- 3. Global burden and Bulgaria**
4. Risk factors and the social gradient
5. Problems

# The global burden: the most widespread diseases of humankind

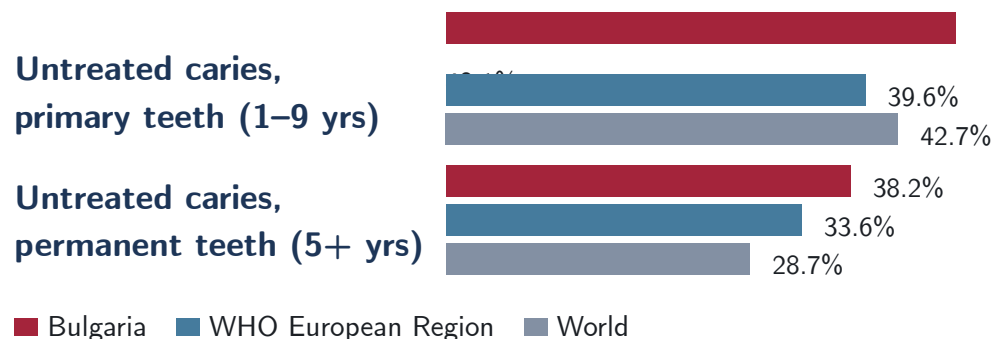
| Condition (2019, GBD)                                        | Cases       | Prevalence     |
|--------------------------------------------------------------|-------------|----------------|
| untreated caries, permanent teeth (5+ yrs)                   | ≈ 2 billion | 28.7%          |
| severe periodontal disease (15+ yrs)                         | ≈ 1 billion | 18.8%          |
| untreated caries, primary teeth (1–9 yrs)                    | 514 million | 42.7%          |
| edentulism (20+ yrs)                                         | 350 million | 6.8%           |
| lip and oral cavity cancer (2020): <b>new cases / deaths</b> | 377,713     | 177,757 deaths |

## What follows

- In total ≈ **3.5 billion** people (GBD 2019) — about 1 billion more than the cases of the five main NCDs combined.
- Cases have grown by more than 1 billion since 1990 (+50%) — mainly due to population growth and ageing.
- Spending on oral care: almost **USD 390 billion** a year.

WHO. Global oral health status report (2022), ISBN 978-92-4-006148-4, tables 2–9; GLOBOCAN 2020; periodontal and edentulism prevalence age-standardised

# Bulgaria, the European Region and the world: untreated caries (GBD 2019)



Only untreated-caries indicators are compared; they are computed the same way (not age-standardised) in all three sources.

## Bulgaria profile (WHO, 2022)

- Severe periodontal disease (15+): **13.9%**; edentulism (20+): **13.5%** (GBD 2019).
- 455 new cases of lip and oral cavity cancer (2020); 3.3 per 100,000 (age-standardised incidence).
- Sugar: **74.4 g/day** per person (availability, not measured intake; 2019).
- Tobacco use 15+ (2019, age-standardised): **39.4%**.
- 9,800 dentists (2019) — **14.0 per 10,000**.
- Spending on dental care: USD 16 per person (2019).

## What Bulgarian studies show

| Study                  | Group                             | Main result                                                                                                                              |
|------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Künzel, 1996 (review)  | 12 yrs, Eastern Europe            | DMFT in Bulgaria <b>3.1</b> — among the lowest in the region                                                                             |
| Ivanova et al., 1995   | 6 yrs, kindergartens              | fluoridated milk (1 mg F on programme days, 180–200 days/yr): dmft <b>40%</b> lower after 3.5 years; the authors note design limitations |
| Onov & Beltcheva, 2020 | 12 yrs, Plovdiv, n = 228          | DMFT <b>1.57</b> in the city and <b>2.92</b> in the villages; caries-free 38.4% vs 17.5%                                                 |
| Kondeva et al., 2026   | 18 yrs, 2 municipalities, n = 480 | quota sample; DMFT <b>7.48</b> : D 3.91, M 0.13, F 3.43 — D is about 52% of DMFT                                                         |

**Local studies show differences: urban–rural, social status and access to care are associated with who carries the burden.**

Künzel W. Int J Paediatr Dent. 1996;6:221–226. doi:10.1111/j.1365-263x.1996.tb00249.x · Ivanova K et al. Adv Dent Res. 1995;9:120–121. doi:10.1177/08959374950090020701 · Onov MP, Beltcheva AB. Folia Med. 2020;62:159–164. doi:10.3897/folmed.62.e47894 · Kondeva V et al. Children. 2026;13:1087. doi:10.3390/children13081087

## CONTENTS

1. Oral health indices
2. WHO methods for oral health surveys
3. Global burden and Bulgaria
- 4. Risk factors and the social gradient**
5. Problems

# Caries: sugars the main risk factor, fluoride the main protective factor

## Free sugars

- Systematic review for WHO (Moynihan & Kelly, 2014): 42 of 50 studies in children found a sugar–caries association; **moderate-quality** evidence that caries is lower when intake is **< 10%** of energy.
- WHO guideline (2015): **< 10%** of energy (strong recommendation), **< 5%** (conditional).
- Both the **amount** and the **frequency** of intake matter.

## Fluoride

- Fluoride toothpaste: prevented fraction **24%** (95% CI 21–28%) — relative reduction of the D(M)FS **increment** in children versus non-fluoride toothpaste (Cochrane, 2003; 70 trials in the meta-analysis).
- Higher concentration → stronger effect; in young children (swallowing while teeth develop) also a higher risk of fluorosis (Walsh et al., 2019).
- Community measures: fluoridation of water, salt or milk.

Moynihan PJ, Kelly SAM. J Dent Res. 2014;93:8–18. doi:10.1177/0022034513508954 · WHO. Guideline: sugars intake (2015) · Marinho VCC et al. Cochrane 2003. doi:10.1002/14651858.CD002278 · Walsh T et al. Cochrane 2019. doi:10.1002/14651858.CD007868.pub3

# Tobacco, alcohol, HPV and the common risk factor approach

## Tobacco, alcohol, diabetes

Smoking is a major risk factor for **periodontitis**; diabetes (hyperglycaemia) also raises the risk. Tobacco and alcohol cause **oral cancer**, with substantially higher risk when combined. In Bulgaria 39.4% of people aged 15+ use tobacco (WHO, 2019).

## HPV and oropharyngeal cancer

SEER, USA, 1988–2004: the incidence of **HPV-positive** oropharyngeal cancer rose by **225%** (from 0.8 to 2.6 per 100,000), while **HPV-negative** cancer fell by 50% (Chaturvedi et al., 2011).

## Common risk factor approach

Sheiham & Watt (2000): sugar, tobacco, alcohol, hygiene and stress are shared by oral diseases, cardiovascular disease, diabetes and cancer. **Population-level** measures — taxes on sugar-sweetened beverages and tobacco, marketing regulation, healthy school environments — act on many diseases at once.

Chaturvedi AK et al. J Clin Oncol. 2011;29:4294–4301. doi:10.1200/JCO.2011.36.4596 · Sheiham A, Watt RG. Community Dent Oral Epidemiol. 2000;28:399–406. doi:10.1034/j.1600-0528.2000.028006399.x

## The social gradient: evidence from the Dunedin cohort (New Zealand)

About 1000 children born 1972–1973, followed from birth; dental examinations at ages 5 and 26.

| At age 26                                                | low childhood SES | high childhood SES |
|----------------------------------------------------------|-------------------|--------------------|
| periodontal disease (attachment loss > 4 mm at ≥ 1 site) | 31.1%             | 11.9%              |
| ≥ 4 surfaces affected by caries                          | 32.2%             | 9.9%               |

Prevalence at age 26 (not incidence). In this study upward social mobility **did not erase** the effect of a disadvantaged childhood (Poulton et al., 2002).

### Gradient by social trajectory

From least to most disease at age 26: **high–high** → low–high → high–low → **low–low** (Thomson et al., 2004).

Oral health inequalities are **stepwise**, not just “poor versus rich” — measures must cover the whole gradient.

Poulton R et al. Lancet. 2002;360:1640–1645. doi:10.1016/S0140-6736(02)11602-3 · Thomson WM et al. Community Dent Oral Epidemiol. 2004;32:345–353. doi:10.1111/j.1600-0528.2004.00173.x · Watt RG et al. Lancet. 2019;394:261–272. doi:10.1016/S0140-6736(19)31133-X

## CONTENTS

1. Oral health indices
2. WHO methods for oral health surveys
3. Global burden and Bulgaria
4. Risk factors and the social gradient
- 5. Problems**

## Problems to solve in class

### Problem 1 - DMFT

Patient aged 35: caries on 16 and 47; fillings on 26, 36, 46; 37 and 18 were present and have been lost (cause unknown); sealant on 27; crown on 11 after trauma. Calculate DMFT.

### Problem 2 - SiC

9 children aged 12: DMFT 0, 0, 1, 1, 2, 3, 3, 6, 8. Calculate mean DMFT, caries-experience prevalence and SiC.

### Problem 3 - Incidence

At the start of the year a care home has 120 residents with at least one natural tooth. All are followed for 1 year; 18 become edentulous. What is the cumulative incidence of edentulism?

### Problem 4 - CFI

50 children: 25 normal, 10 questionable, 10 very mild, 5 mild. Calculate the CFI and interpret it.

## Answers

| Problem | Solution                                                                                                                             | Answer                                                  |
|---------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 1       | D = 2 (16, 47); F = 3 (26, 36, 46); M = 2 (37, 18 — from age 30 all missing teeth count); sealant and crown after trauma not counted | <b>DMFT = 7</b>                                         |
| 2       | sum 24 / 9 = 2.67; caries experience 7 / 9 = 77.8%; SiC = (8 + 6 + 3) / 3                                                            | <b>2.67; 77.8%; 5.67</b>                                |
| 3       | 18 / 120 over 1 year                                                                                                                 | <b>15%</b> over one year                                |
| 4       | $(25 \times 0 + 10 \times 0.5 + 10 \times 1 + 5 \times 2) / 50 = 25 / 50$                                                            | <b>CFI = 0.50</b> — borderline, below the 0.6 threshold |

**Without a denominator, a threshold and a period a number means nothing — check them in every comparison.**

# Summary

## Measurement

1. Prevalence is a “snapshot”; incidence is a “film” of new cases among those at risk.
2. DMFT is **cumulative** caries experience; SiC shows the most affected third.
3. Compare only indices with the **same threshold**, protocol and age.
4. WHO index ages and pathfinder sampling make data comparable.

## Burden and causes

1. Oral diseases affect  $\approx 3.5$  billion people (GBD 2019;  $\approx 3.7$  billion in GBD 2021).
2. Bulgaria: high untreated caries and edentulism, high tobacco use (39.4%).
3. For caries, sugar is the main risk factor and fluoride the main protective factor.
4. Inequalities are **stepwise** and begin in childhood.

Next class: **epidemiological studies**.

Thank you for your attention!