

From a clinical question to a research plan

Research methodology, types of studies and the elements of a research plan-programme in dental medicine

Practical Class 8 · Social Medicine with Medical Ethics · Dental Medicine (English) · 2026/2027

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What you should be able to do after this class

Knowledge

- define scientific research and its stages;
- classify a study by purpose, approach and design;
- name the elements of a research protocol (plan-programme);
- recognise the main threats to validity: chance, bias, confounding.

Skills

- turn a clinical problem into a PICO/PECO question;
- choose a design that can answer it;
- estimate a sample size for a prevalence study;
- draft a plan-programme for a dental study in a group.

The design is chosen by the question — never the other way round.

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1. Research and the scientific method

- 2. The research question
- 3. Types of studies
- 4. Elements of a research protocol
- 5. A worked plan-programme
- 6. Group task

What makes an inquiry “scientific research”?

Scientific research is a systematic, planned and reproducible inquiry that collects and analyses data in order to produce **new knowledge that is generalisable** (quantitative) **or transferable** (qualitative) beyond the people studied.

Its defining features:

- an explicit question and, where appropriate, a **testable hypothesis**;
- a **method decided in advance** and written down (the protocol);
- measurement that others can **repeat and check**;
- honest reporting, including results that disappoint the authors.

The research cycle

observation → question → hypothesis → design → data collection → analysis → interpretation → publication → new questions

Research ≠ clinical audit

An audit assesses local practice **against an explicit existing standard**. Research addresses a question — burden, cause, effect, mechanism or experience — to produce knowledge that applies **beyond the setting studied**.

Classifying research: four independent axes

Axis	Categories	Dental example
Purpose	basic (mechanisms) · applied (diagnosis, treatment, prevention)	biofilm ecology of <i>S. mutans</i> · fluoride varnish trial
Domain	clinical · public health · health services	implant outcomes · school caries survey · access to dental care by income
Approach	quantitative (measurement, statistics) · qualitative (meanings, experiences) · mixed methods (both, deliberately integrated)	DMFT survey · interviews on dental anxiety · anxiety scale + interviews explaining the scores
Control and time	observational vs experimental ; cross-sectional vs longitudinal ; prospective vs retrospective	prevalence survey · cohort followed for decades · randomised trial

Laboratory (in vitro) and animal studies are also research, but they answer questions about mechanisms, not about effects in patients. They have their own reporting guidelines (CRIS, ARRIVE) — week 9.

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From a problem to an answerable question: FINER

	A good question is...
F	Feasible — enough participants, time, money, skills
I	Interesting — to you, to clinicians, to patients
N	Novel — confirms, refutes or extends; check the literature first
E	Ethical — acceptable risk, approvable by an ethics committee
R	Relevant — changes practice, policy or further research

Narrowing a vague interest

“I am interested in caries” →

“Caries in teenagers in Plovdiv” →

“What proportion of 15-year-old schoolchildren in Plovdiv have caries experience (DMFT $\geq$ 1), and is it associated with family socioeconomic position and the frequency of sugar intake?”

Cummings SR, Browner WS, Hulley SB. Conceiving the research question. In: Hulley SB et al. *Designing Clinical Research*. 4th ed. Lippincott Williams & Wilkins; 2013.

Structuring the question: PICO and PECO

PICO — an intervention question

P children and adolescents

I fluoride varnish applied 2–4 times a year

C placebo or no treatment

O caries increment (D(M)FS) after 3 years

Answer: 22 trials, 12,455 children; for permanent surfaces (13 trials) pooled prevented fraction **43%** (95% CI 30–57%) — i.e. a 43% smaller mean D(M)FS increment, not 43% fewer children with caries (Marinho et al., Cochrane 2013).

PECO — an exposure question

P adults receiving dental implants

E smoking

C non-smoking

O implant failure, infection, marginal bone loss

Answer: 107 studies; failure **6.35%** of 19,836 implants in smokers vs **3.18%** of 60,464 in non-smokers (Chrcanovic et al., J Dent 2015) — with uncontrolled confounding.

Add **T** (time) or **S** (setting/study type) when they matter: PICOT, PICOS. For qualitative questions use **PICo** (population, phenomenon of Interest, context).

Aim, objectives and hypotheses

Aim — the general purpose, one sentence.

Objectives (tasks) — specific, measurable steps towards the aim; each objective needs its own variables and analysis (**SMART**: specific, measurable, achievable, relevant, time-bound).

Hypothesis — a testable statement about a relationship, written **before** the data are seen:

- **H₀** (null): no difference / no association;
- **H₁** (alternative): there is a difference or association.

Example (Chrcanovic et al. 2015)

H₀: implant failure rates, postoperative infection and marginal bone loss do **not differ** between smokers and non-smokers.

H₁: they differ.

Result: H₀ rejected for all three outcomes.

Common errors

- a hypothesis for a purely descriptive estimate (a prevalence needs none — unless it is compared with a pre-set benchmark);
- objectives that no variable measures;
- “to prove that...” — research tests, it does not prove.

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A decision tree of study designs

Key question	Design	What it gives
Investigator assigns the exposure at random ?	Randomised controlled trial	effect of an intervention; strongest protection against confounding
Assigns it, but not at random?	Non-randomised (quasi-)experiment	effect, but groups may differ at baseline
Only observes; follows exposed and unexposed from exposure to outcome (prospectively or from past records)?	Cohort study	incidence, relative risk (RR), hazard ratio; temporal sequence
Selects participants by outcome (cases and controls) and compares their exposure?	Case-control study	odds ratio (OR); efficient for rare diseases
Measures exposure and outcome at one time point ?	Cross-sectional study	prevalence, prevalence ratio; no temporal order
Exposure and outcome measured for groups (towns, countries)?	Ecological study	group-level associations; no inference to individuals
No comparison group?	Descriptive : case report/series	hypotheses, signals

Secondary research — **systematic reviews and meta-analyses** — synthesises primary studies. **Qualitative** designs (interviews, focus groups) answer “how” and “why” questions about experience.

Descriptive and cross-sectional studies: measuring the burden

Periodontitis — NHANES 2009–2010

3,742 dentate civilian non-institutionalised US adults ≥ 30 years, full-mouth examination (attachment loss and probing depth at 6 sites per tooth).

47% had periodontitis (8.7% mild, 30.0% moderate, 8.5% severe); **64%** of those ≥ 65 years had moderate or severe disease.

Eke PI et al. J Dent Res 2012;91:914–20.

Oral HPV — NHANES 2009–2010

5,579 people aged 14–69, 30-second oral rinse, HPV DNA by PCR.

Prevalence **6.9%** (95% CI 5.7–8.3); HPV-16 **1.0%**; men 10.1% vs women 3.6%; bimodal age peaks.

Gillison ML et al. JAMA 2012;307:693–703.

Strengths: quick, relatively cheap, give prevalence for planning services, generate hypotheses. **Limit:** exposure and outcome are measured together — we cannot tell which came first.

Global scale

Untreated caries of permanent teeth was the **most prevalent condition worldwide** in 2010: 2.4 billion people (Kassebaum et al. J Dent Res 2015).

Case-control study: starting from the disease

Logic: select **cases** (with the disease) and **controls** (without), then compare past **exposure**. Measure of association: the **odds ratio (OR)**.

HPV and oropharyngeal cancer

100 patients with newly diagnosed oropharyngeal cancer vs 200 controls without cancer (hospital-based).

Oral HPV-16 infection: **OR 14.6** (95% CI 6.3–36.6).

HPV-16 L1 seropositivity: **OR 32.2** (14.6–71.3).

The association held with and without heavy tobacco and alcohol use.

D'Souza G et al. N Engl J Med 2007;356:1944–56.

When to choose it

- rare outcomes (oral and oropharyngeal cancer);
- long latency;
- many exposures can be studied at once.

Typical threats

- **selection bias** — controls must come from the population that produced the cases;
- **recall bias** — cases remember exposures differently;
- no incidence or absolute risk can be calculated.

Cohort study: following people forward in time

Logic: define a group free of the outcome, measure exposure, follow up and count **new cases** (incidence). Measures: **relative risk (RR)**, **hazard ratio (HR)**, risk difference.

Strengths and costs

1. exposure measured **before** the outcome;
2. several outcomes from one exposure;
 - long, expensive, **loss to follow-up**; – inefficient for rare outcomes.

The Dunedin birth cohort (New Zealand)

1,000 children born in 1972–73, assessed at birth and at ages 3, 5, 7, 9, 11, 13, 15 and 26.

At 26 years, those who grew up in **low** vs **high** socioeconomic status families had:

- periodontal disease **31.1% vs 11.9%**;
- a high caries level (authors' definition) **32.2% vs 9.9%**.

Upward social mobility did not eliminate the association.

Poulton R et al. Lancet 2002;360:1640–5.

Randomised controlled trial: the investigator assigns the intervention

OPT trial — periodontal treatment in pregnancy

823 women at 13–17 weeks randomised to scaling and root planing **before 21 weeks** or **after delivery**.

Periodontal measures improved ($P < 0.001$), but preterm birth: **12.0% vs 12.8%**, HR **0.93** (95% CI 0.63–1.37).

→ A reduction in preterm birth was **not demonstrated**; the CI still allows a modest benefit or harm. No safety signal.

Michalowicz BS et al. N Engl J Med 2006;355:1885–94.

Periodontitis and endothelial function

120 patients with severe periodontitis: intensive vs community-based treatment.

Day 1: acute inflammation, **worse** flow-mediated dilatation.

Day 180: flow-mediated dilatation **2.0 percentage points higher** (95% CI 1.2–2.8) — a **surrogate** vascular outcome, not fewer heart attacks.

Tonetti MS et al. N Engl J Med 2007;356:911–20.

Key features

Randomisation — chance decides the group (balances known and unknown confounders). **Allocation concealment** — no one can foresee the next assignment. **Blinding** — participants/examiners do not know the group. **Intention-to-treat** analysis; prospective **registration**.

Lesson

An **association** in observational studies (periodontitis ↔ preterm birth) does not guarantee that **treating** the exposure changes the outcome.

Synthesising evidence and understanding experience

Systematic review and meta-analysis

Explicit question, exhaustive search, predefined inclusion criteria, risk-of-bias assessment, statistical pooling.

Fluoride toothpaste: review of 96 studies; in the 4 trials comparing 1,450–1,500 ppm with non-fluoride toothpaste in children and adolescents the caries increment was lower (SMD -0.36 ; 95% CI -0.43 to -0.29 ; SMD = difference in standard-deviation units).

Walsh T et al. Cochrane Database Syst Rev 2019;CD007868.

Qualitative research

In-depth interviews with 20 adults attending a dental sedation clinic. Dental anxiety affected **physiological, cognitive, behavioural, health and social** domains — sleep, work, relationships, eating and oral hygiene.

Sampling is **purposive**; sample adequacy is justified by information richness and the analytic aim (saturation is one criterion).

Cohen SM, Fiske J, Newton JT. Br Dent J 2000;189:385–90.

In the “new evidence pyramid” the lines between designs are wavy: a well-conducted cohort can be more trustworthy than a poorly conducted trial, and reviews are a lens for viewing evidence, not the top floor (Murad et al., Evid Based Med 2016).

Which design answers which question?

Question	Best feasible design	Main measure
How many 15-year-olds in Plovdiv have untreated caries (DT $\geq$ 1)?	cross-sectional survey	prevalence (95% CI)
Does a school toothbrushing programme reduce new caries?	(cluster) randomised trial	mean difference, RR
Does smoking increase early implant failure?	cohort (prospective or from records)	RR, HR
Is oral HPV-16 a risk factor for oropharyngeal cancer?	case-control	OR
How do patients experience fear of the dentist?	qualitative interviews	themes
What does all the evidence say about fluoride varnish?	systematic review $\pm$ meta-analysis	pooled estimate

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The research protocol (plan-programme): three layers

1 · Conceptual — why?

- title
- problem and rationale (literature)
- aim and objectives
- hypotheses
- expected contribution

2 · Methodological — how?

- design
- **object** and **unit of observation**
- population, eligibility criteria, sample, sampling
- variables (features) and their scales
- methods and instruments
- programme of data collection, processing and analysis

3 · Organisational — who, where, when?

- place and time
- team and responsibilities
- pilot study, timetable (Gantt)
- budget
- ethics approval, data protection
- dissemination

Object of observation (study population) — the set of persons studied (15-year-old pupils in Plovdiv). **Unit of observation** — the element on which features (variables) are recorded (one pupil). **Technical unit** — where data are gathered (the school). Decide also the **unit of analysis**: school, pupil, tooth or surface — several teeth or implants in one person are not independent.

Population, sample and sampling

Target population → source (accessible) population → sampling frame (a list) → sample → respondents.

Probability	Every unit has a known, non-zero chance
simple random	lottery from a full list
systematic	every k-th patient after a random start
stratified	random within strata (region, sex)
cluster	random schools/clinics, then everyone in them

Non-probability	Selection probability unknown
convenience	patients attending our clinic
purposive	chosen for information richness (qualitative)
snowball	participants recruit others
quota	fixed numbers per category

Generalisability

A convenience sample of university-clinic patients describes **those patients**, not the population of Plovdiv.

Sample size: the idea and a worked example

For estimating a **prevalence** with a chosen precision:

$$n = Z^2 \cdot p \cdot (1 - p) / d^2$$

- **Z** = 1.96 for 95% confidence;
- **p** = expected prevalence (from literature or a pilot; 0.50 if unknown — the largest n);
- **d** = acceptable absolute error (margin).

For **comparisons** (two groups, a trial) you also need the expected difference and the **power** (usually 80%) — calculated with software (G*Power, OpenEpi).

Caries experience in 15-year-olds

$p = 0.60$, $d = 0.05$, $Z = 1.96$

$n = 3.8416 \times 0.60 \times 0.40 / 0.0025 = 368.8 \rightarrow$ **369**

$\times$ design effect 2 (cluster sampling of schools) $\rightarrow$ **738**

$\div 0.90$ (10% expected non-response) $\rightarrow$ **820 pupils**

The assumed $p = 0.60$ is a planning value for the exercise; in a real protocol it must be justified by a cited study or a pilot.

Variables: what exactly will be measured?

Role	Example in a caries study
Outcome (dependent)	caries experience — DMFT
Exposure (independent)	frequency of sugary snacks/drinks per day
Confounders	age, sex, socioeconomic position, fluoride tooth-paste use
Effect modifier	e.g. association differs by sex

Operationalisation

DMFT = number of permanent teeth that are **D**ecayed, **M**issing because of caries or **F**illed (WHO criteria; 28 or 32 teeth, depending on whether third molars are counted). A count, often skewed → report the % with $DMFT \geq 1$, mean (SD) **and** median. **DT** ≥ 1 = untreated caries; **DMFT** ≥ 1 = caries experience.

Socioeconomic position → parental education (ordinal), family affluence scale.

Brushing → “twice a day or more / once / less than once” (ordinal).

Scale of measurement — nominal, ordinal, interval, ratio — decides which statistics are valid (weeks 1–7).

Validity: chance, bias and confounding

Chance (random error)

Reduced by an adequate **sample size**; quantified by **confidence intervals** and p-values.

Bias (systematic error)

- **selection**: who gets into the study (volunteers, non-response);
- **information**: measurement error, **recall bias**, uncalibrated examiners;

Prevented mainly by **design and conduct**; a larger sample does not remove it.

Confounding

A common cause of exposure and outcome that creates a non-causal association (e.g. socioeconomic position for smoking ↔ implant failure). A **mediator** on the causal path (smoking → periodontitis → failure) is **not** adjusted away automatically. Control: randomisation, restriction, matching, stratification, multivariable models.

Reliability and validity in dental examinations

Examiners are **calibrated** against a reference examiner; a sample is re-examined and agreement on categorical scores is reported as **Cohen's kappa**. Reliability is not validity: an examiner who always misses early lesions is consistent but wrong. Internal validity comes before external validity (generalisability).

Ethics approval is part of the method, not paperwork

Medical research is carried out only on persons who have given written informed consent after being informed in writing by the head of the research of its nature, significance, scope and possible risks.

— Health Act (Bulgaria), Art. 199(1), author's translation

Medical research is conducted after a positive opinion from a local ethics committee established at the medical or health establishment or the scientific organisation where the research is carried out.

— Health Act, Art. 203(1), author's translation

Also: Art. 197(5) — the participant's interests prevail over scientific and financial interests; Art. 199(3) — consent may be withdrawn at any time; Art. 202(1) — the head of the research is a physician or dentist with a recognised specialty; Art. 203(4) — opinion within 30 days; Art. 201 — joint liability and insurance of the research team.

In practice at MU-Plovdiv

- submit the protocol, information sheet and consent form to the **Research Ethics Committee** of MU-Plovdiv;
- health data are a **special category**: state a lawful basis (GDPR Arts 6 and 9(2)); minimise, pseudonymise, keep the key separate;
- follow the **Declaration of Helsinki** (2024): register the study before the first participant; record amendments.

Vipeholm, Sweden, 1945–1953

Residents of an institution for people with intellectual disabilities were fed sticky sweets between meals to study caries. The findings shaped prevention — but the participants never consented.

Data processing and analysis plan

Objective	Variables	Planned analysis
1. Estimate caries experience	DMFT ≥ 1 (yes/no); DMFT count	prevalence with 95% CI; mean (SD), median (IQR)
2. Compare by socioeconomic position	DMFT; parental education	design-adjusted χ^2 / regression (rank tests assume independent pupils)
3. Association with sugar intake, adjusted	DMFT ≥ 1 ; sugar frequency; confounders	multivariable logistic $\rightarrow$ adjusted prevalence OR, or a prevalence-ratio model
(optional) Model the count	DMFT	negative binomial / Poisson $\rightarrow$ ratio of mean DMFT

All inferential analyses account for the cluster (school/class) design.

Data management

coding manual, validated electronic forms, range checks, pseudonymised IDs; plan for **missing data** and report response rates; software (R, SPSS, jamovi).

Pre-specify

Primary outcome and analysis are fixed **in advance**. Changing them after seeing the data inflates false-positive findings.

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Worked example (1/3): conceptual part

Title

Caries experience and associated social and behavioural factors among 15-year-old schoolchildren in Plovdiv: a cross-sectional study

Rationale. Untreated caries is the most prevalent condition worldwide; the burden is socially patterned (Dunedin cohort). Local data on adolescents guide school prevention.

Aim. To estimate caries experience among 15-year-olds in Plovdiv and its association with socioeconomic position and sugar intake.

Objectives.

1. estimate the prevalence of $DMFT \geq 1$ and the mean DMFT;
2. compare caries experience by parental education and family affluence;
3. assess the association of sugar-intake frequency and toothbrushing with caries, adjusted for confounders.

Hypothesis (obj. 3). H_0 : caries experience does not differ by frequency of sugar intake. Limitation: current behaviour is measured together with cumulative caries history — associations, not causes.

Worked example (2/3): methodological part

Element	Content
Design	cross-sectional, school-based survey
Object of observation	pupils aged 15 years attending general secondary schools in Plovdiv in 2026/2027; excluded: no consent, or a condition that prevents examination
Unit / technical unit	one pupil / the school
Sampling	stage 1: random schools; stage 2: random classes; all eligible pupils in the chosen classes. Invite ≈ 820 to examine ≈ 738 (90% response; design effect 2 is an assumption to justify)
Features (variables)	clinical : DMFT (WHO criteria), plaque index; questionnaire : sex, parental education, family affluence, sugar intake, brushing frequency, fluoride tooth-paste, last dental visit
Methods	clinical examination by 2 calibrated examiners (Cohen's kappa target ≥ 0.80); self-administered questionnaire piloted on 30 pupils

Worked example (3/3): ethics, analysis and organisation

Ethics and data protection

- positive opinion of the MU-Plovdiv Research Ethics Committee;
- permission from the education authority and school principals;
- written informed consent of the pupil and a parent, in the form approved by the ethics committee; right to withdraw;
- pupils with untreated caries receive a referral letter;
- pseudonymised data, stored on university servers.

Organisation

- **place:** selected schools in Plovdiv; **time:** one school year;
- **team:** supervisor (dentist with a recognised specialty), 2 examiners, data manager;
- **timetable:** months 1–3 approvals and pilot; 4–7 field-work; 8–10 analysis; 11–12 report;
- **budget:** examination kits, printing, transport;
- **dissemination:** report to schools, article reported to STROBE.

Analysis: as on the analysis-plan slide. The planning prevalence ($p = 0.60$) must be replaced by a value from a cited study or the pilot.

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Group task: draft a plan-programme (16 minutes)

Work in groups of 3–4. Use the template on the next slide; you will present in **2 minutes** per group.

Group	Topic	Hint
A	Knowledge of oral HPV and its link with oropharyngeal cancer among dental students at MU-Plovdiv	survey; validated questionnaire?
B	Smoking and early implant failure in patients of a university dental clinic	records-based cohort; confounders
C	Twice-yearly fluoride varnish in kindergartens to prevent caries in primary teeth	cluster randomised trial; d(e/m)fs
D	How adults with severe dental anxiety experience treatment under sedation	qualitative; use the PICo variant of the template

First write the question (PICO/PECO), then choose the design — then everything else.

Template for the group plan-programme

1. Title	2. Question (PICO / PECO / PICO)	3. Aim and 2–3 objectives
4. Hypothesis (if analytic)	5. Design and why	6. Object, unit and technical unit
7. Sampling and approximate size (with reasoning)	8. Outcome, exposure, 2 confounders and how each is measured	9. Main bias threat and how you reduce it
10. Analysis for the main objective	11. Ethics: approval, consent, data protection	12. Place, time, team; one practical obstacle

Group D (qualitative): replace 4, 7, 8 and 10 with — approach (e.g. thematic analysis), purposive recruitment and why that number, interview guide topics, analysis, reflexivity and confidentiality. Keep it realistic: what can students with a supervisor do in one academic year?

Presentations and feedback (2 minutes per group)

What the group presents

- the question (PICO / PECO / PICo);
- design and why it fits;
- sample and how it is selected;
- the main threat to validity;
- the ethical issue that needs most attention.

What the class checks

- Can this design **answer** this question?
- Is the comparison group right?
- Is every objective measured by a variable?
- Is it **feasible** in one year?
- Would an ethics committee approve it?

Take-home messages and preparation for week 9

1. A good study starts with a **FINER** question written as **PICO/PECO**.
2. The **question decides the design**: prevalence → cross-sectional; rare disease → case-control; incidence → cohort; effect of an intervention → randomised trial.
3. The plan-programme fixes **object, unit, sample, variables, methods and analysis in advance**.
4. Bias and confounding are handled mainly **at the design stage**; ethics approval and registration come **before** the first participant.

For next week

Week 9: literature review and library sources. Bring a laptop or phone with access to PubMed. Think of a dental topic you would like to read about — you will choose a publication for the **individual critical appraisal assignment**.

Sources used in this class

- Chrcanovic BR, Albrektsson T, Wennerberg A. Smoking and dental implants: a systematic review and meta-analysis. *J Dent*. 2015;43(5):487–98. doi:10.1016/j.jdent.2015.03.003
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- World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human participants. *JAMA*. 2025;333(1):71–4. doi:10.1001/jama.2024.21972
- Health Act (Bulgaria), Arts 197–205, consolidated text, checked 01.11.2026. Regulation (EU) 2016/679 (GDPR), Art. 9.

Questions?

Next week: literature review and critical appraisal