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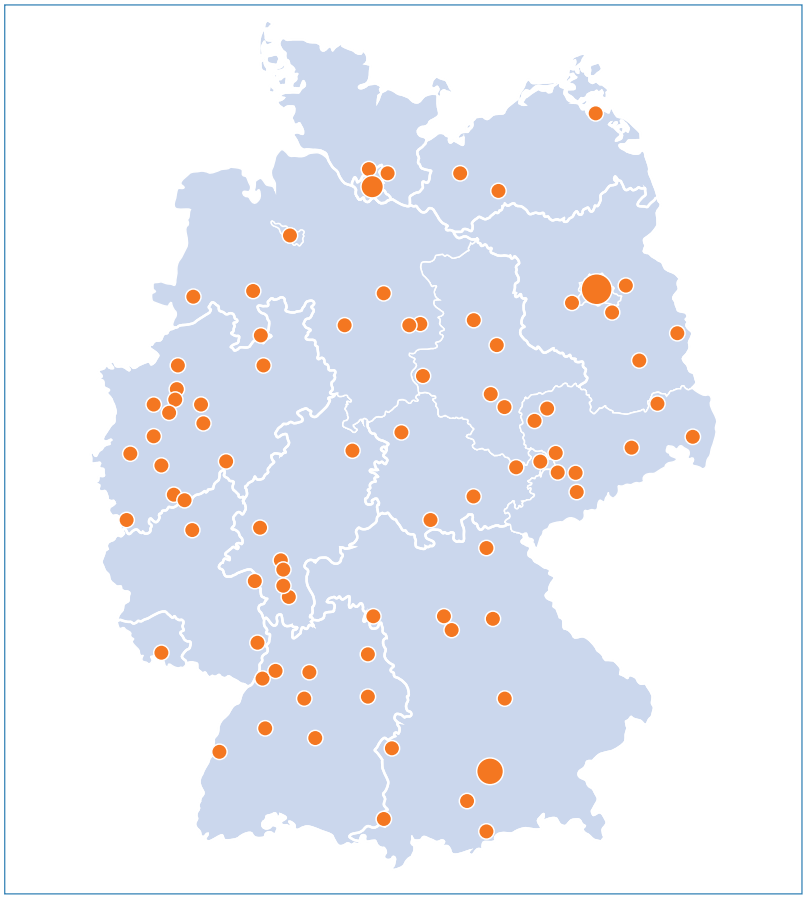


Oral health epidemiology

Clinical examination and social science survey

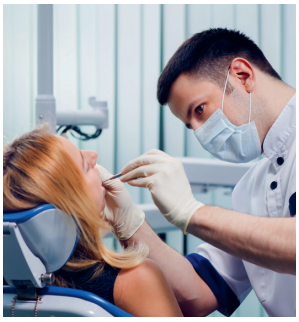
Representative for Germany

Current prevalence

Socio-medical associations

Development of oral health and care status from 1989 to 2023

SIXTH GERMAN ORAL HEALTH STUDY
DMS·6



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DMS • 6: All new !

A. Rainer Jordan, Prof Dr med dent, MSc/Jörg Wiltfang, Prof Dr med Dr med dent/
Werner Geurtsen, Prof Dr med dent/Guido Heydecke, Prof Dr med dent

Is it still relevant for dental students to learn how to make complete dentures and bend clasps for interim prosthetics as the first part of their preclinical training? And is it still appropriate to stop carrying out prophylaxis in kindergartens and schools because caries in children has been conquered?

It would certainly be interesting to hear the answers to these deliberately pointed questions from representatives of university teaching or the public health sector. A key contribution to such discussions will be made by the 6th German Oral Health Study (DMS • 6), a study conducted by the Institute of German Dentists (IDZ) with the support of other scientists, and now published. The DMS • 6 is intended to kick-start the discourse on the needs-based development of dental care in Germany.

The new German Oral Health Study DMS • 6

With this supplement of Quintessence International, you are holding the latest research findings on the oral health situation in Germany. We present a comprehensive picture of the oral health profile of the population in Germany – from early mixed dentition to dentition in the elderly population. We, the IDZ and 12 university professors from the German-speaking European region, dedicate our professional lives to dental research and education. These experts cover the most important fields of dentistry, including cariology, orthodontics, pediatric dentistry, oral medicine, periodontology, dental prosthetics, and implantology, as well as geriatric dentistry. A particular honor for all of us is that this important study is funded solely by the German dental profession. We are deeply grateful to all dentists in Germany. We also thank the German Dental Association (Bundeszahnärztekammer) and the National Association of Statutory Health Insurance Dentists (Kassenzahnärztliche Bundesvereinigung) for their valuable sponsorship and ongoing support. The group of dental experts has been significantly expanded to include researchers and university professors who explore the connections with general medicine, nutritional and behavioral sciences, health economics, social sciences, quality of life research, medical geography, migration, prevention, social medicine, and health services research, making the DMS • 6 a best-practice example of modern social epidemiology.

We also invited all relevant German dental societies to participate in the study planning. Therefore, the DMS • 6 is the most comprehensive oral epidemiology study ever conducted in Germany. Moreover, in addition to a population-representative sample that can be used to assess the current prevalence of oral diseases in the population, participants from the DMS V study were also reexamined for the first time 8 years after their first examination as part of a panel. The development from a purely cross-sectional study is a milestone. Due to the additional longitudinal component, it is now possible to address questions about causal relationships scientifically: For example, what effect does regular participation in individualized prevention have from childhood through adulthood? How are so-called “chalky teeth” (hypomineralization) treated in dental practice? What is the significance of laboratory-made restorations in the age of (self-)adhesive dentistry?

The impressive effectiveness of systematic prevention-oriented dental life-long care are clearly seen in the development of caries in children since the introduction of group and individual prophylaxis in the late 1980s. This paradigm shift has reduced the caries burden in this age group by 90%. But how long does prevention that starts in (early) childhood remain effective? Answers can be derived from the DMS • 6, in which we had the unique opportunity to study the generation that was involved in group and individual prophylaxis during their childhood, now as adults. For example, we found that that fissure sealants can last into adulthood, that tooth loss begins only in the second half of life, and that the prevalence of edentulism has been in a virtual free fall for the past 20 years. These are morbidity dynamics that few would have dreamed of back then. Probably no other chronic disease has seen such large-scale prevention success as dental caries, the most common chronic disease in humans. At the same time, initial scientific data from Andalusia show how quickly the disease returns once caries prevention programs, after their great success, are reduced under the assumption that they are no longer needed.

The significant decline in caries and tooth loss does not, however, imply a diminished role for the dental profession. In DMS V, it was already shown that the treatment burden shifts to older age as a result of morbidity compression. With increasing tooth retention, this process is further intensified: the more teeth that remain in the mouth, the more teeth can or will develop problems as people age (teeth at risk concept).

From a socio-medical perspective, it is noteworthy that the rapid decline in caries in children appears to have stalled. It is conceivable that the COVID-19 pandemic and the resulting disruption of group prophylaxis may have played a role, or it could be a reflection of a changing social structure. Perhaps the law of diminishing marginal utility, when applied to dentistry, can help explain this: The efficacy of current efforts to prevent caries in children may have reached its maximum.

From the perspective of health services research, it will be interesting to observe how effective new population-wide preventive measures for the avoidance of early childhood caries will be after inclusion in the service catalog of statutory health insurance, as individual and group prophylaxis in childhood and adolescence has already influenced caries development in Germany robustly.

This supplement from Quintessence International summarizes the key results of the DMS • 6 in concise thematic units. If you would like to know more, you can access additional results and analyses through the DMS • 6 online portal: https://www.Deutsche-Mundgesundheitsstudie.de.

We hope that this will help pass the time until the next wave of publications on the additional longitudinal results in spring 2026!

With best regards

Prof Dr A. Rainer Jordan, Institut der Deutschen Zahnärzte, Cologne

Prof Dr Dr Jörg Wiltfang, President of the DGZMK e. V.

Prof Dr Werner Geurtsen, Scientific Associate Editor, Quintessence International

Prof Dr Guido Heydecke, Scientific Associate Editor, Quintessence International

A. Rainer Jordan
Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Jörg Wiltfang
Professor and Chair, Department of Oral and Maxillofacial Surgery, University Hospital Schleswig-Holstein, Kiel, Germany

Werner Geurtsen
Professor Emeritus, Department of Conservative Dentistry, Hannover Medical University (MHH), Hannover, Germany

Guido Heydecke
Professor and Chair, Department of Prosthetic Dentistry, University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

A. Rainer Jordan

Jörg Wiltfang

Werner Geurtsen

Guido Heydecke

6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics

A. Rainer Jordan, Prof Dr med dent, MSc/Nicolas Frenzel Baudisch, Dr rer pol/Cristiana Ohm, MA/Fabian Zimmermann, MA/Dominic Sasunna/Constanze Cholmakow-Bodechtel, Dr oec troph, MPH/Marvin Krämer, MSc/Kathrin Kuhr, Dr rer medic

Objectives: With the First German Oral Health Study (DMS I) in 1989, the Institut der Deutschen Zahnärzte (IDZ) laid the foundation for a population-representative socioepidemiologic monitoring of oral health and care status in Germany. The objective of the sixth wave of the survey was to update the status of oral health. **Research questions:** The primary questions address cross-sectional data: 1. What are the current prevalence rates of oral diseases? 2. What associations exist between oral health and other participant characteristics? The third question is based on the comparison of cross-sectional data with previous German oral health studies (trend): 3. How has the oral health and care status in Germany developed from 1989 to 2023? The last two questions require longitudinal data: 4. How do oral diseases change over the course of a lifetime? 5. What individual characteristics influence the progression of (new) oral diseases? **Study design:** The DMS • 6 is a combined cross-sectional and cohort study and therefore classified as an observational study. **Study participants:** The age groups for the cross-sectional study were selected following the World Health Organization (WHO) recommendations for oral epidemiologic studies. These include 12-year-olds as representatives for younger adolescents, 35- to 44-year-olds for younger adults, and 65- to 74-year-olds for younger seniors. An additional age group of 8- and 9-year-olds (younger children) was included to obtain information on oral health during the mixed dentition phase. In total, 3,377 study participants were included in the analyses for the cross-sectional questions (prevalences). Participant characteristics provide insights into their sociodemographic and behavioral parameters. *(Quintessence Int 2025;56 (Suppl):S4–S12; doi: 10.3290/j.qi.b5986173)*

Keywords: cross-sectional studies, dental care, dental health surveys, dentists, DMS 6, epidemiology, Germany, oral health, prevalence, research design

The Institut der Deutschen Zahnärzte (Institute of German Dentists, IDZ) established the foundation for a population-representative socioepidemiologic monitoring of oral health and dental care in Germany with the First German Oral Health Study (DMS I) in 1989.[1] Following German reunification, an additional study (DMS II) was conducted in the new federal states in 1992 to complete the data.[2] The Third German Oral Health Study (DMS III), carried out in 1997,[3] introduced a refined methodologic design that remained largely consistent in subsequent studies, including DMS IV in 2005[4] and DMS V in 2014.[5,6]

The 6th German Oral Health Study (DMS • 6) is the first to be designed as a combined multicenter, nationally representative cross-sectional and longitudinal socioepidemiologic study in this series. Its primary objective is to assess the current status of oral health through clinical examinations while collecting information on oral health behaviors via social science surveys. For the first time, participants from 2014 were reexamined (DMS • 6 cohort), enabling the analysis of individual disease trajectories and incidences. This approach facilitates causal inferences and addresses novel research questions.

The DMS • 6 adhered to the methodologic recommendations of the Working Group for Epidemiology and Public Health of the German Society of Dental, Oral, and Maxillofacial Medicine (DGZMK) and complied with the "Principles of Good Epidemiological Practice" by the German Society for Epidemiology.[7,8]

Participatory health research and expert advisory board

In line with the principles of participatory health research, all relevant German dental scientific societies* were involved in the study planning process through a preliminary consultation and were asked about mandatory and optional examination endpoints.[9] The received proposals (response rate: 53%) were subsequently evaluated during discipline-specific consensus conferences by a dental expert advisory board. The dental expert advisory board for DMS • 6 consists of 12 university professors from the German-speaking European region. This board encompasses key dental specialties, including cariology, orthodontics, pediatric dentistry, oral medicine, periodontology, prosthodontics, implantology, and geriatric dentistry, with most areas represented by at least two experts to ensure a balanced clinical examination program. In addition to the dental expert advisory board, an extended expert panel was established to address supplementary topics. This panel consists of 11 additional researchers from Germany, covering topics such as general medicine, nutrition, health economics, health care utilization behavior, quality of life, medical geography, migration history, oral hygiene behavior, prevention, smoking behavior, social medicine, and health care research.[10]

Study objectives and research questions

The DMS • 6 is an oral epidemiology study with the main objective of reporting on the oral health situation in Germany. Therefore, it focuses on dentistry and aims to draw conclusions from the sample to the resident population of Germany. The study's primary goals relate to descriptive epidemiology, involving the documentation of oral health, oral health behaviors, and dental care status. The secondary goal encompasses analytical epidemiology, seeking explanations for observed phenomena.

The overarching research questions can be grouped into three categories—cross-sectional, trend, and longitudinal—requiring different types of data. The first two questions are based on cross-sectional data:

1. What are the current prevalence rates of oral diseases?
2. What associations exist between oral health and other participant characteristics?

The third question is based on the comparison of cross-sectional data with previous German oral health studies (trend):

3. How has the oral health and care status in Germany developed from 1989 to 2023?

The last two questions require longitudinal data:

4. How do oral diseases change over the course of a lifetime?
5. What individual characteristics influence the progression of (new) oral diseases?

Study design

DMS • 6 is a combined cross-sectional and cohort study, conducted as a survey involving clinical examinations and interviews, classifying it as an observational study. Like its predecessors, it includes cross-sectional surveys representative of selected age groups in Germany (DMS • 6 cross-section). The age groups were selected following the World Health Organization (WHO) recommendations for oral epidemiologic studies. These groups were: younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds), collectively referred to as WHO age groups.[11] In addition, the study included a group of younger children (8- and 9-year-olds) to address questions about malocclusions and oral health during the mixed dentition phase. This alignment with WHO standards enables both international comparisons and national comparisons with previous studies of similar design.

The current report focuses on the cross-sectional component of the study. Findings from the longitudinal component, involving participants reexamined from the DMS V (DMS • 6 cohort), are planned for publication in 2026.

Sample size planning

The sample size for the cross-sectional component of DMS • 6 was determined to address two primary goals. First, it needed to be sufficient to answer cross-sectional research questions regarding the current prevalences of oral diseases in Germany.

*Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde (DGZMK), Deutsche Gesellschaft für Alterszahnmedizin (DGAZ), Arbeitsgemeinschaft Zahnmedizin für Menschen mit Behinderung oder besonderem medizinischem Unterstützungsbedarf (AG ZMB), Deutsche Gesellschaft für Funktionsdiagnostik und -therapie (DGFDT), Deutsche Gesellschaft für Implantologie (DGI), Deutsche Gesellschaft für Kieferorthopädie (DGKFO), Deutsche Gesellschaft für Kinderzahnheilkunde (DGKiZ), Deutsche Gesellschaft für Parodontologie (DG PARO), Deutsche Gesellschaft für Prothetische Zahnmedizin und Biomaterialien (DGPro), Deutsche Gesellschaft für Zahnerhaltung (DGZ), Deutsche Gesellschaft für orale Epidemiologie und Versorgungsforschung (DGoEV), Arbeitskreis Psychologie und Psychosomatik (AK PP), Interdisziplinärer Arbeitskreis Oralpathologie und Oralmedizin (AK OPOM), Deutsche Gesellschaft für Präventivmedizin (DGPZM), Deutsche Gesellschaft für Restaurative und Regenerative Zahnerhaltung (DGR2Z), Deutsche Gesellschaft für Endodontologie und zahnärztliche Traumatologie (DGET).

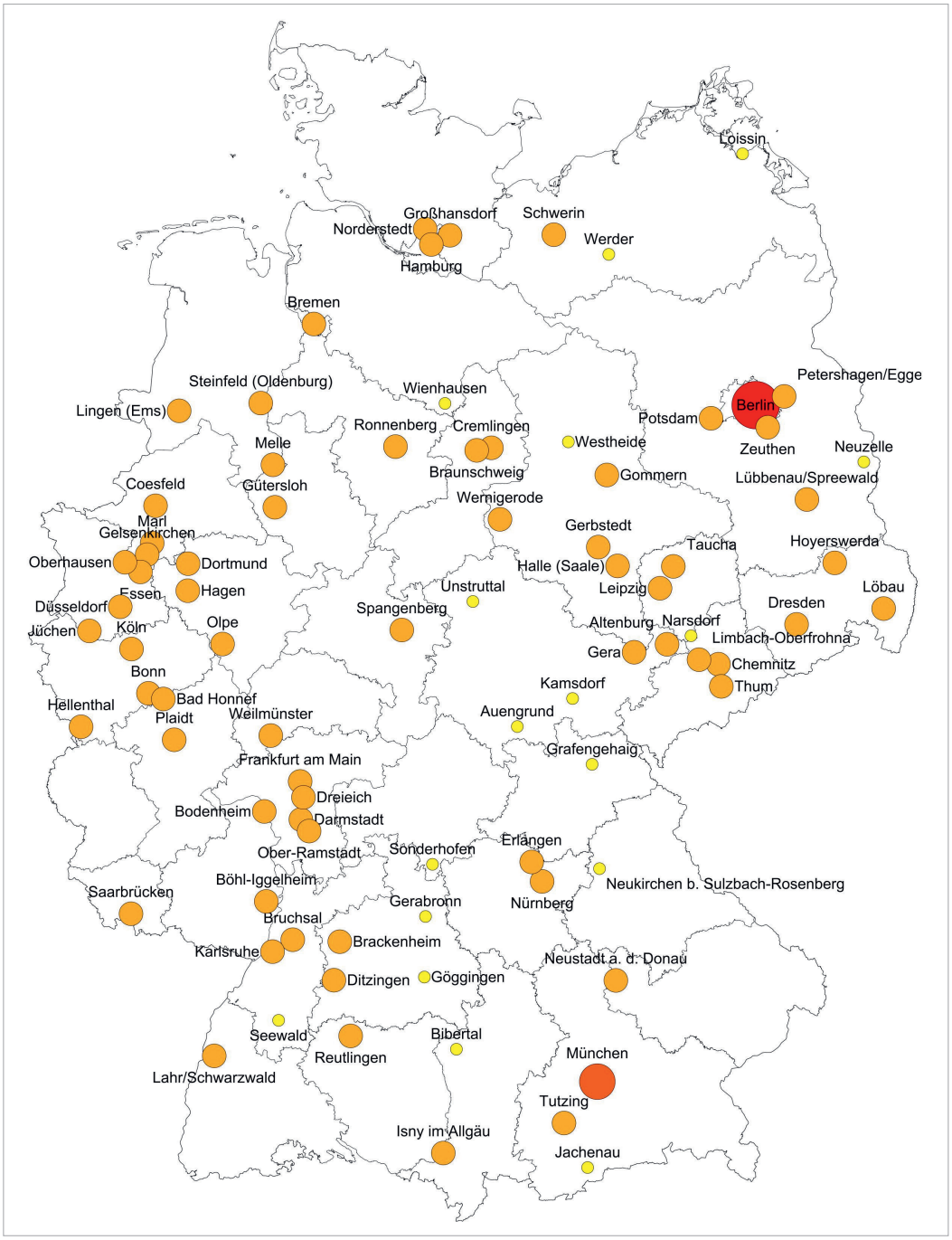

Fig 1 Map of the DMS • 6 examination centers.

Second, it was essential to ensure enough participants for a potential follow-up survey (DMS • 7), planned for around 2030. Initially, the target sample sizes for the WHO age groups mirrored those of previous oral health studies, aiming to recruit 1,000 new participants per age group. However, due to significant recruitment challenges, the target sample sizes were adjusted during the field phase to ensure successful study completion.

The revised sample size goals were:

- younger children (8- and 9-year-olds): 670 participants
- younger adolescents (12-year-olds): 900 participants
- younger adults (35- to 44-year-olds): 900 participants
- younger seniors (65- to 74-year-olds): 750 participants.

Further details regarding the sample size calculations are provided in Appendix 1.

Population and inclusion/exclusion criteria

The target population of DMS • 6 consisted of individuals registered as residents in Germany, who belong to the specified birth cohorts, have sufficient proficiency in the German language to participate in the study, and are both mentally and physically capable of completing the study protocol.

To be included in the cross-sectional survey, participants had to meet all the following inclusion criteria:

- The individual was registered in one of the selected sampling municipalities
- The individual was born in one of the following years:
  - 2011–2012 (younger children, 8- and 9-year-olds)† OR
  - 2010 (younger adolescents, 12-year-olds) OR
  - 1978–1987 (younger adults, 35- to 44-year-olds) OR
  - 1948–1957 (younger seniors, 65- to 74-year-olds)
- The individual or their legal representatives provided written informed consent.

Participants were excluded if they met any of the following exclusion criteria:

- The individual or their legal representatives lacked sufficient German language proficiency to participate in the study
- The study could not proceed due to legal constraints.

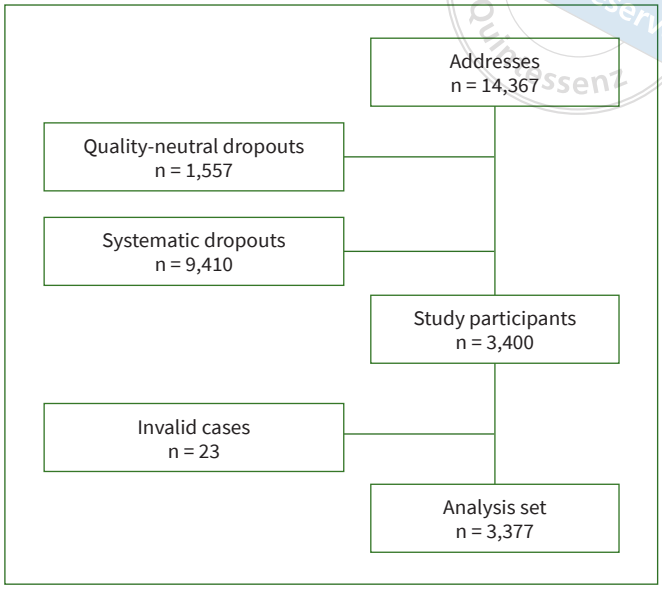

Fig 2 Flow chart of study participants.

Sampling model

The objective of the sampling model was to represent the selected population groups in Germany as accurately and unbiasedly as possible. To achieve this, a two-stage sampling method using a disproportionate stratified random sample was employed.

In the first stage, municipalities were selected. For DMS • 6, the 90 municipalities from DMS V were retained. In DMS V, all municipalities in Germany were stratified by federal state, administrative region, and district, as well as by BIK community types (classification 0 to 9). An allocation calculation was then conducted based on the distribution of the target population at the time of DMS V sampling in September 2013, covering four age groups (12-year-olds; 35- to 44-year-olds; 65- to 74-year-olds; 75- to 100-year-olds). This ensured a representative selection of 90 municipalities based on geographic criteria, reflecting the distribution of Germany's population across urban and rural areas. To ensure representativeness for specific age groups in the new federal states, 30 sampling points were allocated to these states and 60 to the old federal states (Fig 1). For the group of younger children (8- and 9-year-olds), 16 municipalities—one per federal state—were additionally included.[12]

In the second stage, individual participants were randomly selected from the registers of residents in the identified municipalities. This selection process was managed by the internationally contracted field institute, Cerner Enviza (now Oracle Life Sciences). The institute contacted local registration offices to request addresses, explaining the legitimate public interest and specifying the parameters and criteria for selection. Address selection occurred approximately 3 to 6 months before the start of fieldwork.

To determine the number of addresses to request per age group, an expected response rate of 36% was assumed. For 1,000 interviews per age group, 2,778 addresses needed to be contacted (1,000 / 0.36 = 2,778). Since a random selection from the delivered addresses was required, twice this number of addresses was requested. For each of the three WHO age groups, 6,050 addresses were initially requested, divided between 31 large cities (100 addresses per age group) and 59 smaller munic-

†The examination of the 8- and 9-year-olds was conducted from January to March 2021.

Table 1 Response rate and sample utilization by age groups (DMS • 6 cross-section)

	Total, n (%)	8- and 9-year-olds, n (%)	12-year-olds, n (%)	35- to 44-year-olds, n (%)	65- to 74-year-olds, n (%)
Unadjusted gross sample	14,367	1,892	3,102	5,287	4,086
Adjusted gross sample	12,810 (100.0%)	1,759 (100.0%)	2,834 (100.0%)	4,567 (100.0%)	3,650 (100.0%)
Valid realized examinations / net sample (RR2 according to AAPOR*)	3,400 (26.5%)	714 (40.6%)	959 (33.8%)	929 (20.3%)	798 (21.9%)

*Response rate 2 according to the American Association for Public Opinion Research.[14]

ipalities (50 addresses per age group). As the fieldwork progressed, it became clear that the assumed response rate of 36% was not achievable. Therefore, the total number of addresses was incrementally increased. In total, 1,892 younger children, 3,102 younger adolescents, 5,287 younger adults, and 4,086 younger seniors were contacted. This resulted in adjusted response rates of 40.6% (714 participants, younger children), 33.8% (929 participants, younger adolescents), 20.3% (929 participants, younger adults), and 21.9% (798 participants, younger seniors).

Details on the geographic sampling process for DMS V and the sampling model for younger children have been published elsewhere.[12,13]

From the gross sample to the analysis set

In total, 14,367 individuals were initially contacted and invited to participate in the study (Fig 2). This number represents the unadjusted gross sample. Of these, 1,557 individuals were excluded and classified as quality-neutral dropouts (14.2% of all exclusions, 10.8% of the gross sample). Additionally, there were 9,410 systematic dropouts (85.8% of all exclusions, 65.5% of the gross sample). The distribution of these dropouts is detailed in Appendix 2. After excluding the quality-neutral and systematic dropouts, 23 additional cases were removed from the statistical data analysis, resulting in a final analysis set of 3,377 cases. The data analysis included participants for whom at least three central dental outcome measures (caries, periodontitis, and edentulism) were recorded. In the age group of younger adolescents (12-year-olds), only two central outcomes (caries and edentulism) were required. Missing data from the social-science survey did not lead to the exclusion of participants from the analysis.

The response rate was calculated in alignment with the American Association for Public Opinion Research's Response Rate 2[14] standard and mirrored the methodology used in the second wave of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS Wave 2).[15] The response rate represents the ratio of participants included in the analysis set (n = 3,400) to the gross sample adjusted for quality-neutral dropouts (n = 12,810) (Table 1).

Characterization of the study participants

A total of 3,400 participants from the age groups of younger children, younger adolescents, younger adults, and younger seniors were examined, with 3,377 cases included in the analyses.[12,16] These participants were distributed as follows:

- younger children (8- and 9-year-olds): n = 695
- younger adolescents (12-year-olds): n = 958
- younger adults (35- to 44-year-olds): n = 927
- younger seniors (65- to 74-year-olds): n = 797.

The characteristics of the study participants are presented in Tables 2 (younger children and younger adolescents) and 3 (younger adults and younger seniors).

Further methodologic information

Detailed information on fieldwork, data collection, and quality assurance is described by Ohm et al.[16] Detailed information on data handling and statistical methods is described by Kuhr et al.[17]

The DMS • 6 was approved by the Institutional Review Board of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). Prior to the start of fieldwork, the study was registered at the German Clinical Trials Register (registration number DRKS00028701).

Table 2 Characteristics of the study participants for younger children (8- and 9-year-olds) and younger adolescents (12-year-olds)

Variable		8- and 9-year-olds	12-year-olds
No. of participants (n)		695	958
Age, years		8.5 ± 0.5	12.7 ± 0.5
	Missing	0	0
Gender	Male	366 (52.7%)	484 (50.5%)
	Female	329 (47.3%)	473 (49.4%)
	Diverse	NA	1 (0.1 %)
	Missing	0	0
Education group	Low	54 (7.8 %)	84 (9.5%)
	Medium	353 (51.1%)	420 (47.4%)
	High	284 (41.1%)	383 (43.2%)
	Missing	4	71
Socioeconomic status	Low	99 (16.2%)	161 (20.6%)
	Medium	399 (65.4%)	458 (58.7%)
	High	112 (18.4%)	161 (20.6%)
	Missing	85	178
Monthly net equivalent income, Euro		2,007 ± 1,380	2,033 ± 1,094
	Missing	78	162
Migration history	People with migration history	160 (23.2%)	220 (24.6%)
	People without migration history	531 (76.8%)	676 (75.4%)
	Missing	4	62
Body mass index, kg/m^2		NA	19.5 ± 3.9
	Underweight or normal weight	NA	693 (85.6%)
	Overweight	NA	70 (8.6%)
	Obesity	NA	47 (5.8%)
	Missing	NA	148
Self-assessment of general health status	Very poor	0 (0.0%)	2 (0.2%)
	Poor	1 (0.1%)	0 (0.0%)
	Moderate	61 (8.8%)	47 (5.0%)
	Good	310 (44.7%)	470 (49.8%)
	Very good	322 (46.4%)	425 (45.0%)
	Missing	1	14
Self-assessment of oral health status	Very poor	2 (0.3%)	0 (0.0%)
	Poor	8 (1.2%)	12 (1.3%)
	Moderate	217 (31.4%)	204 (21.7%)
	Good	355 (51.4%)	512 (54.4%)
	Very good	108 (15.7%)	214 (22.7%)
	Missing	5	16
Locus of control*	None	NA	1 (0.1%)
	Little	NA	30 (3.2%)
	Some	NA	199 (21.2%)
	Much	NA	496 (52.9%)
	Very much	NA	211 (22.5%)
	Missing	NA	21
Dental service utilization	Regular check-ups	567 (81.6%)	848 (90.0%)
	Occasional check-ups	69 (9.9%)	37 (3.9%)
	Complaint-oriented	59 (8.5%)	57 (6.1%)
	Missing	0	16
Dental visits (frequency)	Only in case of problems	54 (7.8%)	40 (4.3%)
	< once a year	38 (5.5%)	7 (0.7%)
	≥ once a year	187 (26.9%)	166 (17.8%)
	≥ once every 6 months	416 (59.9%)	721 (77.2%)
	Missing	0	24
Health insurance status	Statutory health insurance	580 (84.9%)	663 (74.8%)
	Statutory health insurance + supplementary health insurance	30 (4.4%)	104 (11.7%)
	Private health insurance	73 (10.7%)	115 (13.0%)
	Other	0	2 (0.2%)
	No health insurance	0	2 (0.2%)
	Missing	12	72
Tooth brushing (frequency)	< once daily	12 (1.7%)	24 (2.5%)
	Once daily	120 (17.3%)	124 (13.1%)
	2 times daily	544 (78.3%)	744 (78.7%)
	> 2 times daily	19 (2.7%)	53 (5.6%)
	Missing	0	13
Interdental cleaning (frequency)	≥ once daily	NA	141 (14.9%)
	≥ once a week	NA	93 (9.8%)
	< once a week	NA	113 (12.0%)
	Never	NA	598 (63.3%)
	Missing	NA	13
Current cleaning by parents	Yes	245 (35.8%)	NA
	No	439 (64.2%)	NA
	Missing	11	NA
Fluoride toothpaste use	Yes	608 (94.9%)	827 (95.9%)
	No	33 (5.1%)	35 (4.1%)
	Missing	54	96
Fluoridated salt use	Usually no	NA	125 (16.4%)
	Occasionally	NA	144 (18.9%)
	Usually yes	NA	493 (64.7%)
	Yes	448 (65.3%)	NA
	No	188 (27.4 %)	NA
	Don't know	50 (7.3%)	NA
	Missing	9	196
Intake of fluoride tablets	Yes	11 (1.6%)	NA
	No	675 (97.7%)	NA
	Don't know	5 (0.7%)	NA
	Missing	4	NA
Fluoride gel use for oral hygiene	Yes	103 (15.8%)	NA
	No	550 (84.2%)	NA
	Missing	42	NA

Data are presented as number (percentage) or mean ± standard deviation based on unweighted data.
*How much can you do yourself to maintain or improve your dental health?
NA, not available.

Table 3 Characteristics of study participants for younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds)

Variable		35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)		927	797
Age, years		40.1 ± 2.9	69.8 ± 2.8
	Missing	1	1
Gender	Male	459 (49.5%)	375 (47.1%)
	Female	467 (50.4%)	422 (52.9%)
	Diverse	1 (0.1%)	0 (0.0%)
	Missing	0	0
Education group	Low	80 (9.2%)	158 (20.9%)
	Medium	408 (46.8%)	367 (48.6%)
	High	383 (44.0%)	230 (30.5%)
	Missing	56	42
Socioeconomic status	Low	154 (19.9%)	112 (19.2%)
	Medium	435 (56.1%)	345 (59.2%)
	High	186 (24.0%)	126 (21.6%)
	Missing	152	214
Monthly net equivalent income, Euro		2,433 ± 1,406	1,996 ± 1,042
	Missing	128	144
Migration history	People with migration history	201 (23.3%)	105 (13.9%)
	People without migration history	662 (76.7%)	648 (86.1%)
	Missing	64	44
Body mass index, kg/m²		26.2 ± 5.5	27.4 ± 5.0
	< 25	414 (47.9%)	242 (32.4%)
	25 – < 30	287 (33.2%)	311 (41.7%)
	≥ 30	164 (19.0%)	193 (25.9%)
	Missing	62	51
Smoking status	Never smoked	503 (54.6%)	380 (48.0%)
	Former smoker	182 (19.7%)	299 (37.8%)
	Occasional smoker	54 (5.9%)	12 (1.5%)
	Daily smoker	183 (19.8%)	101 (12.8%)
	Missing	5	5
Cardiovascular disease	Yes	39 (4.2%)	216 (27.3%)
	No	883 (95.8%)	575 (72.7%)
	Missing	5	6
Diabetes mellitus	Type 1 diabetes	4 (0.4%)	1 (0.1%)
	Type 2 diabetes	19 (2.1%)	124 (15.7%)
	No diabetes or gestational diabetes	896 (97.5%)	664 (84.2%)
	Missing	8	8
Self-assessment of general health status	Very poor	8 (0.9%)	7 (0.9%)
	Poor	18 (2.0%)	43 (5.4%)
	Moderate	86 (9.3%)	184 (23.2%)
	Good	469 (50.9%)	435 (54.9%)
	Very good	340 (36.9%)	123 (15.5%)
	Missing	6	5
Self-assessment of oral health status	Very poor	13 (1.4%)	12 (1.5%)
	Poor	32 (3.5%)	56 (7.1%)
	Moderate	204 (22.2%)	218 (27.6%)
	Good	492 (53.5%)	430 (54.4%)
	Very good	178 (19.4%)	75 (9.5%)
	Missing	8	6
Locus of control*	Very much	314 (34.2%)	192 (24.6%)
	Much	450 (49.0%)	382 (49.0%)
	Some	137 (14.9%)	193 (24.7%)
	Little	15 (1.6%)	10 (1.3%)
	None	2 (0.2%)	3 (0.4%)
	Missing	9	17
Dental service utilization	Regular check-ups	732 (79.4%)	662 (83.7%)
	Occasional check-ups	68 (7.4%)	26 (3.3%)
	Complaint-oriented	122 (13.2%)	103 (13.0%)
	Missing	5	6
Health literacy†	Never	826 (89.6%)	721 (91.0%)
	Rarely	39 (4.2%)	30 (3.8%)
	Sometimes	22 (2.4%)	18 (2.3%)
	Often	16 (1.7%)	11 (1.4%)
	Always	19 (2.1%)	12 (1.5%)
	Missing	5	5
Scheduling difficulties‡	Yes	47 (5.2%)	35 (4.5%)
	No	852 (94.8%)	740 (95.5%)
	Missing	28	22
Dental visits (frequency)	Only in case of problems	84 (9.2%)	80 (10.2%)
	< once a year	39 (4.3%)	17 (2.2%)
	≥ once a year	368 (40.2%)	265 (33.7%)
	≥ once every 6 months	425 (46.4%)	424 (53.9%)
	Missing	11	11
Periodontal treatment (utilization)	Yes	116 (12.7%)	255 (32.3%)
	No	776 (84.7%)	503 (63.8%)
	Don't know	24 (2.6%)	31 (3.9%)
	Missing	11	8
Professional tooth cleaning (frequency)	Never	193 (21.2%)	165 (21.9%)
	Usually no professional tooth cleaning	108 (11.9%)	94 (12.5%)
	< once a year	115 (12.6%)	76 (10.1%)
	≥ once a year	318 (34.9%)	223 (29.7%)
	≥ once every 6 months	176 (19.3%)	194 (25.8%)
	Missing	17	45
Health insurance status	Statutory health insurance	523 (61.2%)	461 (62.1%)
	Statutory health insurance + supplementary health insurance	240 (28.1%)	168 (22.6%)
	Private health insurance	85 (9.5%)	110 (14.8%)
	Other	6 (0.7%)	3 (0.4%)
	No health insurance	1 (0.1%)	0
	Missing	72	55
Use of bonus booklet	Yes	460 (50.3%)	291 (37.0%)
	No	455 (49.7%)	495 (63.0%)
	Missing	12	11
Tooth brushing (frequency)	< once daily	26 (2.8%)	30 (4.0%)
	Once daily	139 (15.1%)	93 (12.5%)
	2 times daily	711 (77.1%)	535 (72.1%)
	> 2 times daily	46 (5.0%)	84 (11.3%)
	Missing	5	55
Interdental cleaning (frequency)	≥ once daily	224 (24.3%)	283 (38.1%)
	≥ once a week	199 (21.6%)	125 (16.8%)
	< once a week	190 (20.6%)	62 (8.4%)
	Never	309 (33.5%)	272 (36.7%)
	Missing	5	55
Fluoride toothpaste use	Yes	800 (95.9%)	647 (93.6%)
	No	34 (4.1%)	44 (6.4%)
	Missing	93	106
Fluoridated salt use	Usually no	146 (19.4%)	149 (22.0%)
	Occasionally	129 (17.1%)	91 (13.5%)
	Usually yes	479 (63.5%)	436 (64.5%)
	Missing	173	121

Data are presented as number (percentage) or mean ± standard deviation based on unweighted data.
*How much can you do yourself to maintain or improve your dental health?
†How often do you need help from someone when reading instructions, patient information leaflets, or other written materials from your doctor or pharmacist?
‡Difficulties with scheduling an appointment with the dentist in the last 12 months.

Disclosure

ARJ, CO, FZ, DS, and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and the author of the manuscript. NFB is the former deputy principal investigator and responsible for the social science study setting. CO is project manager for DMS • 6 and a co-author of the manuscript. FZ is responsible for the social science analysis and a co-author of the manuscript. DS is the data manager of DMS • 6 and jointly responsible for statistical data preparation and analysis. CCB was responsible for the organization of the fieldwork and is a co-author of the manuscript. MK was responsible for the data review and preparation as well as the analysis of the current field progress and is a co-author of the manuscript. KK is the deputy principal investigator of DMS • 6, responsible for the data analysis, and a co-author of the manuscript.

References

1. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in der Bundesrepublik Deutschland. Ergebnisse des nationalen IDZ-Survey 1989. Cologne: Deutscher Ärzte-Verl., 1991.

2. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in Ostdeutschland. Ergebnisse des IDZ-Ergänzungssurvey 1992. Cologne: Deutscher Ärzte-Verl., 1993.

3. Micheelis W, Reich E (eds). Dritte Deutsche Mundgesundheitsstudie (DMS III). Ergebnisse, Trends und Problemanalysen auf der Grundlage bevölkerungsrepräsentativer Stichproben in Deutschland 1997. Cologne: Deutscher Ärzte-Verl., 1999.

4. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006.

5. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

6. Jordan RA, Bodechtel C, Hertrampf K, et al. The Fifth German Oral Health Study (Fünfte Deutsche Mundgesundheitsstudie, DMS V) - rationale, design, and methods. BMC Oral Health 2014;14:161.

7. Schiffner U, Jordan AR, Micheelis W. Wissenschaftliche Mitteilung zu Zielen und Methoden der epidemiologischen Erfassung oraler Erkrankungen: Arbeitskreis Epidemiologie und Public Health (AKEPH) der Deutschen Gesellschaft für Zahn-, Mund- und Kieferheilkunde (DGZMK). Dtsch Zahnärztl Z 2010;65:496–502.

8. Deutsche Gesellschaft für Epidemiologie. Leitlinien und Empfehlungen zur Sicherung von Guter Epidemiologischer Praxis (GEP): Langversion. Hannover: DGEpi, 2018.

9. Bach M, Jordan S, Hartung S, Santos-Hövener C, Wright MT. Participatory epidemiology: the contribution of participatory research to epidemiology. Emerg Themes Epidemiol 2017;14:2.

10. Institut der Deutschen Zahnärzte (IDZ). Projektleitung der Sechsten Deutschen Mundgesundheitsstudie (DMS • 6) des Instituts der Deutschen Zahnärzte (IDZ). Cologne: Institut der Deutschen Zahnärzte, 2024. https://www.idz.institute/leuchtturmprojekte/deutsche-mundgesundheitsstudien/studie/projektleitung/. Accessed date 31 Jan 2025.

11. World Health Organization. Oral health surveys: Basic methods (5th Edition). Geneva: World Health Organization, 2013.

12. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N. Methodology of the Sixth German Oral Health Study (DMS 6) to survey tooth and jaw misalignment. J Orofac Orthop 2023;84(Suppl 1):10–18.

13. Cholmakow-Bodechtel C, Füßl-Grünig E, Micheelis W. Probandenstichproben, Durchführung der Feldarbeit und Reichweitenabschätzung. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016:53–78.

14. American Association for Public Opinion Research. Standard definitions. Final dispositions of case codes and outcome rates for surveys, 9th edition. Alexandria: AAPOR, 2016.

15. Hoffmann R, Lange M, Butschalowsky H, et al. Querschnitterhebung von KiGGS Welle 2 – Teilnehmendengewinnung, Response und Repräsentativität. J Health Monit 2018;3:82–96.

16. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

17. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

A. Rainer Jordan

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Nicolas Frenzel Baudisch Senior Researcher, infas Institute for Applied Social Science, Bonn, Germany; until 2023: Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Cristiana Ohm Project manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Fabian Zimmermann Senior Researcher, Institut der Deutschen Zahnarzte (IDZ), Cologne, Germany

Dominic Sasunna Data manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Constanze Cholmakow-Bodechtel Director Research Consulting, Public Health & Epidemiology, Oracle Life Sciences (Oracle Deutschland B.V. & Co. KG), Munich, Germany

Marvin Krämer Senior Research Consultant, Public Health & Epidemiology, Oracle Life Sciences (Oracle Deutschland B.V. & Co. KG), Munich, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Appendix 1 and 2

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/6th-german-oral-health-study-dms-6-rationale-study-design-and-baseline-characteristics-online-appendix/

6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance

Cristiana Ohm, MA/Kathrin Kuhr, Dr rer medic/Fabian Zimmermann, MA/Nicolas Frenzel Baudisch, Dr rer pol/ Constanze Cholmakow-Bodechtel, Dr oec troph, MPH/Marvin Krämer, MSc/A. Rainer Jordan, Professor Dr med dent, MSc

Objectives: The German Oral Health Studies (DMS) are nationally representative surveys on oral health in Germany, conducted approximately every 8 years since 1989. The current sixth edition of the study (DMS • 6) was planned and executed in accordance with international standards. A field institute selected from across Europe was responsible for data collection. **Method and materials:** For six age groups, data collection for the DMS • 6 took place across Germany from October 2022 to September 2023. Data for a seventh age group had already been collected earlier, in the spring of 2021. In addition to conducting a cross-sectional study with new participants, for the first time, a longitudinal component was included by reengaging study participants from the previous study, the Fifth German Oral Health Study (DMS V). Participation was organized via postal invitations, followed by reminder letters or personal visits if there was no response. Data collection in the field was conducted at temporarily established study centers. **Data collection:** The primary aim of the DMS • 6 was to assess the current oral health status, oral health behavior, and the dental care status in Germany. For this purpose, both new study participants and participants from the preceding DMS V study underwent clinical examinations and social science surveys. The clinical examinations followed a standardized protocol outlined in a manual. The social science survey was conducted in two parts: a paper and pencil interview (PAPI) completed at home and a computer-assisted personal interview (CAPI) administered immediately before the clinical examination in the study center. A non-response survey showed no systematic differences between study participants and non-participants, indicating an unbiased data basis. **Quality assurance:** The DMS • 6 included a comprehensive examination program supported by a multi-stage quality assurance system. This system involved pre-testing of the social science research instruments, conducting a pilot study to simulate the main study, multiple training sessions, and the calibration and certification of the dental study personnel both before and during fieldwork. This ensured a high level of data validity. *(Quintessence Int 2025;56 (Suppl):S14–S21; doi: 10.3290/j.qi.b5981986)*

Keywords: data collection, dental care, dental health surveys, dentists, DMS 6, epidemiology, surveys and questionnaires

The German Oral Health Studies (DMS) are oral epidemiologic surveys aimed at reporting the state of oral health in Germany. They are the only nationally representative studies of their kind. Since 1989, the oral health of selected individuals has been assessed approximately every 8 years. This complements the federal government's epidemiologic health reporting in Germany.[1]

Following a Europe-wide call for tenders, the field institute Cerner Enviza (now Oracle Life Sciences) in Munich was identified to conduct this sixth edition of the study, being primarily responsible for recruiting study participants and collecting data. The collaboration between the field institute and project management was marked by regular and intensive consultations.

The 6th German Oral Health Study (DMS • 6) included a comprehensive examination program, accompanied by a multi-stage quality assurance system. In particular, the detailed training of the study personnel and reliability testing before and during the study were essential. These measures ensured that any measurement distortions were promptly identified and appropriate countermeasures implemented. The study adhered to current international standards for dental and social science data collection.[2,3]

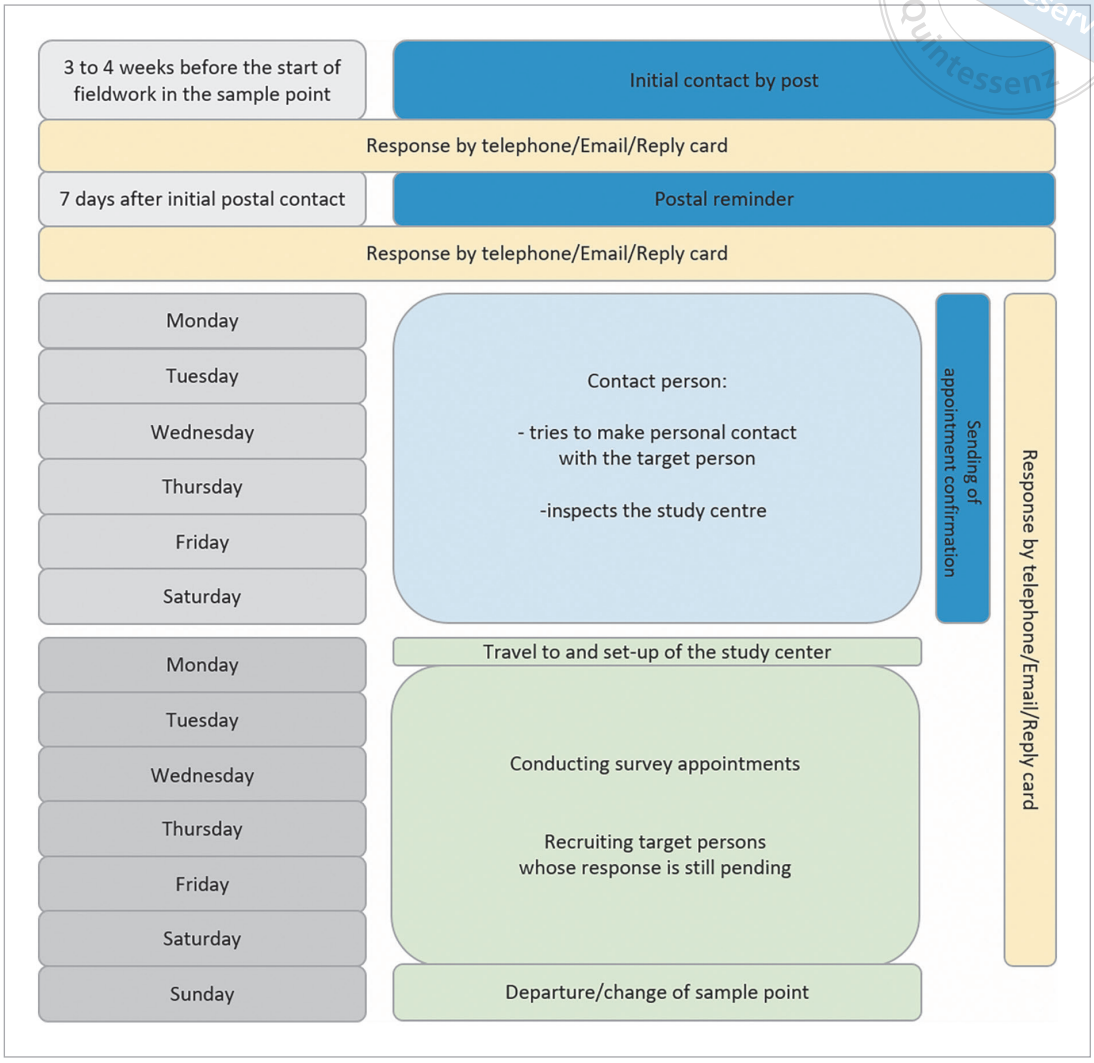

Fig 1 Schematic representation of fieldwork for a sample point.

Method and materials

The DMS • 6 has been approved by the Institutional Review Board of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701). Further details regarding research objectives, study design, and characteristics of the study participants are published elsewhere.[4]

Recruiting study participants

The main survey of the DMS • 6 began on 4 October 2022, and continued until 22 July 2023. During this period, the study teams traveled simultaneously across Germany to conduct clinical examinations and social science interviews with study participants from six age groups in 90 study centers.[4,5] Each study team consisted of a contact person, a dental practitioner, and an interviewer. Throughout the entire field phase, four contact persons, five dental practitioners, and six interviewers were involved in data collection.

The six age groups surveyed from October 2022 to July 2023 included:

- younger adolescents (12-year-olds)
- older adolescents (20-year-olds)
- younger adults (35- to 44-year-olds)
- older adults (43- to 52-year-olds)
- younger seniors (65- to 74-year-olds)
- older seniors (73- to 82-year-olds).

A subsequent data collection took place immediately after the main survey, continuing until 23 September 2023, aimed at achieving the targeted net number of cases in the group of younger adults. For organizational and health policy reasons, the clinical examinations and social science surveys for a sev-

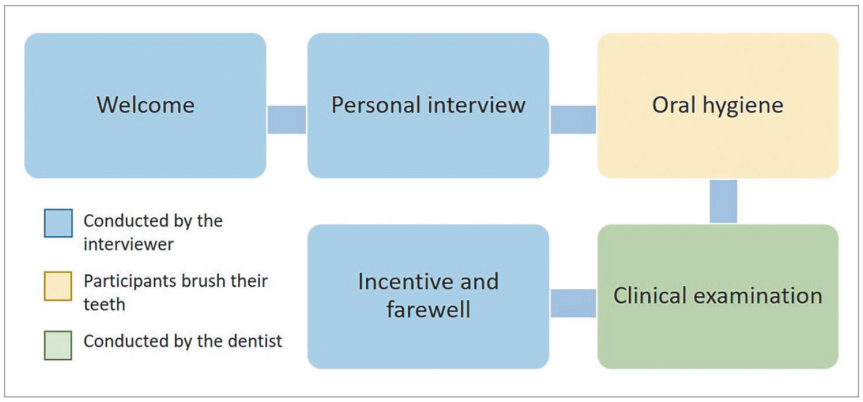

Fig 2 Organization of processes in the study center from the perspective of the study participants.

enth age group (younger children: 8- and 9-year-olds) were conducted beforehand in the spring of 2021 and were described in detail elsewhere.[6,7]

For the first time, in addition to examining new study participants (the cross-sectional component of the DMS • 6), a repeated examination of participants from the DMS V was conducted (the longitudinal component of the DMS • 6). The age groups of younger children, younger adolescents, younger adults, and younger seniors were examined cross-sectionally, allowing for the determination of oral epidemiologic disease prevalences. The age groups of older adolescents, older adults, and older seniors were part of the DMS V study panel, enabling the determination of incidence rates; results will be reported in spring 2026.

Conducting fieldwork

Figure 1 provides a schematic overview of the fieldwork conducted at one sample point. Postal invitations to participate in the study were coordinated with a route plan defined at the start of the study. Four weeks prior to the fieldwork, the identified target individuals or their legal guardians received an invitation letter to visit the study center. Along with it, they received an information sheet about the study. The field institute maintained a free telephone hotline for study participants to address queries regarding the study or to arrange individual appointments. Additionally, study participants could respond via email or by using a reply card included with the invitation letter. If no response was received within 7 days of sending the invitation, a reminder letter was dispatched. Study participants who confirmed their attendance received appointment confirmations by post, which included the consent form, the data protection sheet, and a paper questionnaire to be completed by the study participant. These documents were to be brought along to the examination appointment. If a mobile number was provided, a reminder was sent via SMS the day before the appointment. Individuals who did not respond to either the invitation or reminder letters were visited in person by a contact person in the week prior to the planned examination week to arrange an appointment.

The study team spent 2 weeks on-site for each sample point. In the first week, the contact person inspected the rented premises where the temporary study center would be established. It was ensured that there were at least two rooms or one large room that could be divided by screens. The premises were located in public buildings such as hotels, office buildings, youth hostels, or similar venues.

During the second week, the interviewer and dental practitioner were on-site to conduct the surveys and examinations over a period of 6 days. On the morning of the first day, the study center was set up, which included an interview area, a mobile tooth brushing station, and an area for clinical examinations. Upon arrival at the study center, the study participants were guided through the planned examination program by the study team. Figure 2 illustrates this process from the perspective of the study participants.

Initially, the interviewer welcomed the study participants and, if applicable, their accompanying persons. After this welcome, the interviewer collected the data protection sheet, the declaration of consent, and the completed paper questionnaire that had been sent to the study participant's home address in advance. Following this, a computer-assisted personal interview (CAPI) was conducted. In preparation for the clinical examination, the study participants were then asked to brush their teeth at the mobile tooth brushing station. Study participants were encouraged to bring and use their own dental care items,

Table 1 Clinical examinations by age group

Examination	12-year-olds	20-year-olds	35- to 44-year-olds	43- to 52-year-olds	65- to 74-year-olds	73- to 82-year-olds
Dental findings	x	x	x	x	x	x
Periodontal findings	—	x	x	x	x	x
Caries	x	x	x	x	x	x
Root caries	—	—	x	x	x	x
Molar-incisor hypomineralization (MIH)	x	x	—	—	—	—
Erosions	—	x	x	x	—	—
Dentures	—	—	x	x	x	x
Oral mucosa findings	—	—	—	—	x	x
Plaque	x	x	x	x	x	x
Oral functional capacity	—	—	—	—	x	x

x, recorded; —, not recorded.

though alternatives were provided. For selected age groups (12-year-olds, 20-year-olds, 35- to 44-year-olds, and 65- to 74-year-olds), tooth brushing was filmed in a standardized manner for further evaluation, provided the study participants consented. Afterward, the dental practitioner conducted the clinical examination, recording clinical data in input masks on a laptop. At times, the interviewer assisted the dental practitioner. After their visit, the study participants received a monetary incentive.

Data collection

The primary aim of the DMS • 6 data collection was to assess the current oral health status, oral health behavior, and the dental care status. To achieve this, a clinical examination, a paper and pencil interview (PAPI), and a CAPI were conducted. The characteristics to be recorded were selected based on contemporary oral epidemiologic standards. Efforts were also made to ensure sufficient compatibility with the previous DMS study; however, due to methodologic developments, direct comparability with DMS V is not fully achievable in all aspects.[8] The project management team, in collaboration with an international and interdisciplinary group of experts, defined both the dental and the social science study endpoints.[9]

The study endpoints for the six aforementioned age groups are presented below. The dental and social science data collection for the seventh age group of younger children (8- and 9-year-olds) has been described in detail elsewhere.[6,7] Detailed information on data processing and statistical analysis has also been published elsewhere.[10]

Collecting dental data

The clinical examination program included dental findings, periodontal findings, caries, root caries, molar-incisor hypomineralization (MIH), erosions, dentures, oral mucosa findings, plaque, and oral functional capacity. An overview of the recorded study endpoints by age group can be found in Table 1. The criteria for clinical data collection regarding the dental study endpoints were detailed in a manual for clinical examination.[11] Standardized work instructions for conducting the examinations by the study dental practitioners were derived from this manual. The data were recorded electronically using the specially created program DentaSoft 6.

Since data collection in the field could not occur under the same conditions as in a dental practice, all necessary precautions were taken to ensure the highest possible quality of the examination. The examination room was set up to meet the requirements of a clinical examination. A basic examination chair allowing the study participants to be placed in a semi-reclined position was situated near a window, avoiding direct sunlight. Because no suction was available, study participants were permitted to swallow regularly during the examination. Additionally, as saliva removal using compressed air was also not possible, dental cotton rolls were used to manage saliva. As is usual in clinical examinations, further details were attended to once the study participants were positioned. For instance, the available headlamp and floor lamp were adjustable for the examination of both the maxillary and mandibular arches. Disposable instruments, such as the Variator Dental Kit and Brillant No. 5 Dispos-

Table 2 Social science topics by age group

Interview mode	Topic	12-year-olds	20-year-olds	35- to 44-year-olds	43- to 52-year-olds	65- to 74-year-olds	73- to 82-year-olds
Paper and pencil interview (PAPI)	Fluoride prophylaxis	x	x	x	x	x	x
	Health economics	x	x	x	x	x	x
	Migration	x	x	x	x	x	x
	Oral health-related quality of life	x	x	x	x	x	x
	Disability and need for care	(x)	(x)	(x)	(x)	x	x
	Sociodemographics	x	x	x	x	x	x
	Socioeconomic status	x	x	x	x	x	x
	Dental anxiety	—	x	x	x	x	x
	Sugar consumption	x	x	x	x	x	x
Computer assisted personal interview (CAPI)	Health literacy	—	x	x	x	x	x
	Home care services	—	—	—	—	x	x
	Dental service utilization	x	x	x	x	x	x
	Cardiometabolic diseases	—	—	x	x	x	x
	Medical geography	—	x	x	x	x	x
	Oral hygiene behavior	x	x	x	x	x	x
	Smoking status	—	x	x	x	x	—
	Self-assessment of health status	x	x	x	x	x	x
	Health services research	—	x	x	x	x	x
	Orthodontic treatment	x	x	x	x	x	x
	Full denture wearer	—	—	—	—	x	x

x, recorded; —, not recorded; (), reduced inclusion.

able dental mirror (Hager & Werken), as well as sterilized instruments such as the periodontal probe PCPUNC 15 (Zantomed) for periodontal measurements, were utilized. The study adhered to general hygiene requirements for clinical examination procedures to prevent infections or cross-infections.

Collecting social science data

The social science survey comprised two separate interviews conducted at different times and utilizing different modes. The aim of this two-part design was to employ the most suitable mode for each question. Furthermore, this approach also enabled the inclusion of more questions across two shorter interviews than would have been feasible in a single, longer questionnaire. One single, longer questionnaire would have required shortening to minimize dropouts.

The first part of the social science data collection involved an age-specific paper questionnaire for a written interview (PAPI). The study participants or their legal guardians were asked to complete this questionnaire at home and then bring it with them to the appointment at the study center. The second part was conducted at the study center, where the interviewer used an age-specific CAPI.[11] Table 2 provides an overview of the topics covered in each questionnaire mode and for each age group.

Non-response survey

A non-response survey was conducted to gain insights into any potential systematic differences between study participants and non-participating target individuals regarding key indicators. Five weeks after the conclusion of the fieldwork, a brief two-page questionnaire was sent to target individuals or their legal guardians who had not responded or had declined to participate (Appendix 1). All questionnaires received by the field institute by 22 January 2024 were included in the non-response analysis. The questionnaire included questions about

various sociodemographic and oral health indicators, such as gender, year of birth, length of residence in Germany, employment status, German citizenship, self-assessment of oral health status, and frequency of dental visits.

A total of 9,644 target individuals were contacted, of whom 1,568 completed and returned the questionnaire. Specifically, 1,114 people mailed back the written paper questionnaire by post, while 454 opted to complete the questionnaire online, resulting in a response rate of 16.3% for the non-response survey. The evaluation revealed no systematic differences between study participants and non-participants, indicating an unbiased data basis (Appendix 2).

Quality assurance

The DMS • 6 data were collected approximately 9 years after the DMS V study. While the current study's approach was based on the framework of previous DMS studies, it was considerably expanded. For instance, the DMS • 6 is significantly more comprehensive due to its new longitudinal component.[4] Furthermore, to ensure a high level of data validity, a multi-stage quality assurance system was implemented both prior to and during fieldwork. This process allowed for evaluations that optimized procedures at each stage of data collection. In addition, it enabled follow-up training sessions for the study personnel.

Pretest

Both DMS • 6 questionnaires, PAPI and CAPI, included new items that had not been included in previous DMS studies. To ensure these items effectively fulfilled their intended purpose, some were tested in a cognitive pretest. Four different pretest techniques were applied across a total of 30 interviews with children, adults, and seniors: retrospectively thinking aloud, behavior coding, cognitive probing, and paraphrasing. These techniques covered a range of topics such as migration history, medical geography, health economics, dental service utilization, oral hygiene behavior, and health status. The topics were discussed semi-qualitatively with pretest participants via video call or in person. The sessions lasted between 30 and 45 minutes. Based on the findings from these interviews, the PAPI and CAPI survey instruments were refined.

Pilot study

Prior to the main study, a pilot study was conducted to test the planned study procedures. This pilot study simulated the main study on a smaller scale, with all primary processes, including data collection, carried out as planned for the main study. This approach allowed for early assessment of timing and procedural optimization. Conducted 6 months before the start of fieldwork, the 1-week pilot study included a total of 20 study participants from various age groups. This setup enabled testing of the entire data pathway—from study participant to dataset—under real-world conditions.

Training, calibration, and reliability testing

Before the start of fieldwork, the DMS • 6 study teams received training from the study group, including the study management, the field institute, and the scientific experts. This training covered the history and procedures of the DMS • 6 study and was delivered through an in-person event and multiple online sessions. Training videos on clinical examinations created by the experts were made available throughout the entire field phase for initial and follow-up training. Theoretical knowledge was assessed with a written examination following the training.

To assess and minimize observer bias, calibration and a reliability test were conducted for the dental personnel by the scientific experts. This included inter- and intra-observer variability assessments for selected dental characteristics (eg, dental status: tooth present/tooth missing; carious tooth surface: yes/no; probing depth in mm). Agreement between study personnel and the scientific experts (gold standard) was evaluated using the intraclass correlation coefficient (ICC) calculated for continuous variables, with Bland-Altman plots provided, and the Cohen kappa coefficient (κ) for categorical variables. Predefined thresholds for passing the reliability test were ICC = 0.5 and κ = 0.6, indicating moderate to good agreement, respectively.[12,13] These thresholds were selected based on the endpoints to be assessed and the conditions of data collection in the field. Personnel who did not meet the quality standards received additional individual follow-up training from the experts, both online and in person. Following the initial reliability test before the field launch, two further reliability tests were conducted during the field phase. Across all tests, inter-individual agreement on dental status between study personnel and the gold standard was good to very good (κ: 0.68 to 1.00), as was intra-individual agreement between two measurements (κ: 0.93 to 1.00). Regarding the gold standard, the intra-individual agreement was κ = 1.00. For probing depths, ICC values for inter-individual agreement ranged from 0.48 to 0.81 and intra-individual agreement from 0.68 to 0.90,

with the gold standard's intra-observer ICC at 0.79. Regarding carious tooth surfaces, ICC values for the study personnel ranged from 0.35 to 0.71 (inter-individual) and from 0.40 to 0.97 (intra-individual), respectively. The intra-observer value of the gold standard was 0.89. Further methodologic details and results are available in Appendix 3.

The principal investigator (ARJ) supervised the study teams during the initial fieldwork week, enabling immediate clarification of issues during on-site training. Alongside the three reliability tests, regular statistical monitoring and analysis of collected data helped identify anomalies and provided a basis for additional training as necessary.

Monitoring

Throughout the entire field period, the field institute and the study management conducted multiple on-site visits with each study team to ensure that the fieldwork processes were implemented as planned. Key aspects were assessed using a standardized checklist. The findings were summarized in a report shared with the DMS • 6 study group. Following data collection, the field institute provided an interim report detailing response rates by age group and gender, along with any notable observations.

In summary, the complexity of the DMS • 6 was managed through comprehensive quality assurance measures, which ensured a high level of data validity.

Disclosure

CO, KK, FZ, and ARJ are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. CO is project manager for the DMS • 6 and the author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. FZ is responsible for the social science analysis and a co-author of the manuscript. NFB was deputy principal investigator until October 2023 and is a co-author of the manuscript. CCB was responsible for the organization of the fieldwork and is a co-author of the manuscript. MK was responsible for the data review and preparation as well as the analysis of the current field progress and is a co-author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript.

References

1. Gesundheitsberichterstattung des Bundes (GBE). GBE - Gesundheitsberichterstattung des Bundes; 2024. https://www.gbe-bund.de/gbe/. Accessed 2 Sep 2024.
2. World Health Organization. Oral health surveys: Basic methods (5th Edition). Geneva: WHO, 2013.
3. Deutsche Gesellschaft für Epidemiologie. Leitlinien und Empfehlungen zur Sicherung von Guter Epidemiologischer Praxis (GEP): Langversion. Hannover: DGEpi, 2018.
4. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl):S4–S12.
5. Cholmakow-Bodechtel C, Füßl-Grünig E, Micheelis W. Probandenstichproben, Durchführung der Feldarbeit und Reichweitenabschätzung. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016:53–78.
6. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N. Methodology of the Sixth German Oral Health Study (DMS 6) to survey tooth and jaw misalignment. J Orofac Orthop 2023;84(Suppl 1): 10–18.
7. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N, Kirschneck C. Sechste Deutsche Mundgesundheitsstudie (DMS • 6). Cologne: Zahn- und Kieferfehlstellungen bei Kindern, 2021.
8. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.
9. Institut der Deutschen Zahnärzte (IDZ). Projektleitung der Sechsten Deutschen Mundgesundheitsstudie (DMS • 6) des Instituts der Deutschen Zahnärzte (IDZ); 2024. https://www.idz.institute/leuchtturmprojekte/deutsche-mundgesundheitsstudien/studie/projektleitung/. Accessed date 31 Jan 2025.
10. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.
11. Institut der Deutschen Zahnärzte (IDZ). Ergebnisportal der Deutschen Mundgesundheitsstudie • 6; 2025. https://www.Deutsche-Mundgesundheitsstudie.de (available here: Studienüberblick/Methodik). Accessed 17 March 2025.
12. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med 2016;15: 155–163.
13. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–174.

Cristiana Ohm

Cristiana Ohm Project manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Fabian Zimmermann Senior Researcher, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Nicolas Frenzel Baudisch Senior Researcher, infas Institute for Applied Social Science, Bonn, Germany; until 2023: Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Constanze Cholmakow-Bodechtel Director Research Consulting, Public Health & Epidemiology, Oracle Life Sciences (Oracle Deutschland B.V. & Co. KG), Munich, Germany

Marvin Krämer Senior Research Consultant, Public Health & Epidemiology, Oracle Life Sciences (Oracle Deutschland B.V. & Co. KG), Munich, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Correspondence: Institut der Deutschen Zahnärzte (IDZ), DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

Appendix 1 to 3

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/6th-german-oral-health-study-dms-6-fieldwork-data-collection-and-quality-assurance-online-appendix/.

6th German Oral Health Study (DMS • 6): data processing and statistical methods

Kathrin Kuhr, Dr rer medic/Dominic Sasunna/Nicolas Frenzel Baudisch, Dr rer pol/Vinay Pitchika, PhD/ Fabian Zimmermann, MA/Cristiana Ohm, MA/A. Rainer Jordan, Prof Dr med dent, MSc

Objectives: The 6th German Oral Health Study (DMS • 6) is a combined cross-sectional and cohort study with the main objective of reporting oral diseases in Germany. Based on cross-sectional data, current prevalence estimates and trend analyses on the development of oral health and care status in Germany were conducted using representative data. Associations between oral health and further participant characteristics were examined. The aim of this article is to provide details on data handling and statistical analysis of the cross-sectional data. **Sample weighting:** Weighting factors were used as part of the statistical analysis to correct for deviations between the analysis set and the population structure in Germany. The objective was to make nationwide representative statements for the age groups examined in the cross-sectional component of the DMS • 6. Different types of weights were calculated: design, non-response, and calibration weights. **Processing of quantitative variables:** The indices and transformed variables required for data analysis were defined based on variables collected in clinical examinations and social science interviews. Dental characteristics were aggregated at the participant level. **Statistical methods:** For epidemiologic description, prevalence rates and means with associated 95% confidence intervals were calculated. Regression models were adjusted to estimate the strength of associations between participant characteristics of interest and oral health-related outcomes. To describe trends in the temporal development of oral health and dental care status in Germany, epidemiologic descriptions from DMS • 6 and previous studies were compared. *(Quintessence Int 2025;56 (Suppl):S22–S29; doi: 10.3290/j.qi.b5981988)*

Keywords: cross-sectional studies, data analysis, data management, dental care, dentists, DMS 6, epidemiologic studies

The 6th German Oral Health Study (DMS • 6) is an oral epidemiologic and social science survey conducted on a nationally representative level. It aligns directly with the five preceding oral health studies the Institut der Deutschen Zahnärzte (IDZ) conducted since 1989.[1-5] The objective of these studies has been to provide health reporting on oral diseases in Germany.

The DMS • 6 is a combined cross-sectional and cohort study and, as such, is an observational study. Like its predecessors, it includes cross-sectional surveys representative of Germany for selected age groups (DMS • 6 cross-section). The age groups were defined according to the World Health Organization (WHO) recommendations for oral epidemiologic studies.[6] These included 12-year-olds, representing younger adolescents; 35- to 44-year-olds, representing younger adults; and 65- to 74-year-olds, representing younger seniors (referred to as WHO age groups hereafter). Additionally, a group of 8- and 9-year-old younger children was included in the study to obtain information on oral health during mixed dentition, alongside questions on dental and jaw malocclusions. Three other age groups were examined as part of the first follow-up survey of the DMS V (DMS • 6 cohort). For the 20-year-olds (older adolescents), 43- to 52-year-olds (older adults), and 73- to 82-year-olds (older seniors), newly collected data were linked on an individual basis with DMS V data, enabling longitudinal analyses for the first time within the framework of the German Oral Health Studies.

The cross-sectional component of DMS • 6 enabled current prevalence estimates and trend analyses of oral health and care status development in Germany based on representative data. Cross-sectional data facilitated the examination of associations between oral health and additional participant characteristics. The individually linkable longitudinal data from the DMS • 6 cohort further provide an opportunity to analyze

changes in oral diseases over the life course, as well as their protective and risk factors.

This article aims to detail the processing steps from the collected raw data through data handling and statistical analysis methods to the reporting of study results. It describes specifics on sample weighting, processing of quantitative variables, and statistical methodologies relevant to the overall study evaluation. Additionally, more specific information can be found in individual result articles on various dental and social science topics. The following sections report on the processing of cross-sectional data. Details on the processing of longitudinal data will be published at a later date (2026). The examination of 8- and 9-year-olds was conducted in a preliminary field phase; details on weighting, data handling, and statistical methodology have been described elsewhere and are not part of this article.[7,8]

The DMS • 6 has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample weighting

Weighting factors were applied as part of the statistical analysis to correct deviations between the analysis set and the population structure in Germany. The objective was to enable nationwide representative statements for the age groups examined in the cross-sectional component of the DMS • 6.

In the following, the estimation of weighting factors for the three WHO age groups is described. Each age group was treated as a separate sample to be weighted. Different types of weights were calculated: design weights, non-response weights, and calibration weights.

Design weights were calculated as the inverse of the study participant selection probability. The sample design was considered at this step, as the sampling design of DMS • 6 was set up disproportionately across the German federal states.[9] Additionally, variations in the sizes of sample points were accounted for.

Non-response weighting aimed to align the net sample (study participants) with the originally drawn gross sample. For this purpose, meta-data available from the gross sample was used. Responses from the non-response survey were not included, as the discrepancies between the net sample of the main study and the net sample of the non-response survey were marginal.[10] To calculate the weighting factors, multivariable logistic regression models were used, estimating the probability of study participation based on explanatory variables such as federal state, gender, age, BIK municipality size class, and nationality. Non-response weighting was the second step after design weighting and provided the basis for a modified design weight, calculated as the product of the non-response weight and the design weight. This weighting adjusts for unequal selection probabilities due to the sample design and, simultaneously, for varying participation probabilities.

After applying the first two weighting steps, calibration weighting was performed to further align with known population characteristics. The calibration weight was based on the modified design weight. As a reference for population totals, data from official statistics (official population projections as of 31 December 2022, Microcensus 2022) were used.[11,12] Calculation of the weighting factors was conducted through an iterative marginal calibration procedure, considering key characteristics such as federal state, gender, age, BIK municipality size class, nationality, household size, and education. The calibration weight factors were restricted to a range between 0.2 and 5.0. Finally, normalization to the number of study participants was performed.

Processing of quantitative variables

The clinical examination program included assessments of dental findings, periodontal findings, caries, root caries, molar-incisor hypomineralization (MIH), erosions, dentures, oral mucosa findings, plaque, and oral functional capacity. The clinical examinations were conducted according to a standardized manual. Most quantitative variables were recorded not at the participant level but at the tooth level, tooth surface level, or jaw level, for example. For data analysis, these variables were appropriately aggregated to the participant level, such as by the number or proportion of affected teeth, the presence of a finding (prevalence), or as the arithmetic mean across all surfaces examined. During data aggregation, all available values were used, with no requirement for complete data. Unless otherwise specified, variable calculations were based on data for 28 teeth, excluding third molars (exception: edentulism). An overview of variables from the clinical examinations is provided in Table 1.

The social science surveys collected information on topics including sociodemographics (eg, age, gender, education status, income, migration history), oral hygiene behavior (eg, toothbrushing frequency, interdental cleaning frequency), dental service utilization (eg, dental visits, professional tooth cleaning), general health (eg, diabetes mellitus, cardiovascular diseases), oral health-related quality of life, smoking behavior,

Table 1 Overview of variables from the clinical examinations

Topic	Variable	
Dental findings	Full dentition (yes | no)	
	Edentulism (based on 32 teeth; yes | no)*	
	Number of teeth	
	Number of missing teeth total / replaced / not replaced	
	Restorations	Fillings (yes | no)
		Partial crowns/inlays (yes | no)
		Full crowns (yes | no)
Caries	Coronal caries	Number of decayed, missing, filled surfaces (DMFS, DS, MS, FS)
		Number of decayed, missing, filled teeth (DMFT, DT, MT, FT)
		Number of filled and sound teeth (FST, ST)
		(dynamic) Significant Caries Index (SiC, dSiC)
		Caries experience (DMFT > 0; yes | no)
		Caries-free (DMFT = 0; yes | no)
		Number of teeth with active initial lesions
		Fissure sealing (yes | no)
		Number of sealed teeth
	Root caries	Root Caries Index (RCI; %)
		Root caries (yes | no | edentulous)
		Number of teeth with active root or secondary lesions
		Number of teeth with filled root surfaces
Periodontal findings	Bleeding on probing (BOP)	BOP (% sites)
	Probing depth (PD)†	Mean PD (mm)
		PD ≥ 4 mm / ≥ 6 mm (yes | no)
		Number of teeth with PD ≥ 4 mm / ≥ 6 mm
		Percentage of sites with PD ≥ 4 mm / ≥ 6 mm (%)
	Clinical attachment level (CAL)†	Mean CAL (mm)
		CAL ≥ 3 mm / ≥ 5 mm (yes | no)
		Number of teeth with CAL ≥ 3 mm / ≥ 5 mm
		Percentage of sites with CAL ≥ 3 mm / ≥ 5 mm (%)
	EFP/AAP classification	Periodontitis status and stage (periodontal health | gingivitis | periodontitis case: stage I / II / III / IV | edentulous | non-classified)
		Periodontitis grade (grade A | grade B | grade C)
	CDC/AAP case definition (no or mild periodontitis | moderate periodontitis | severe periodontitis | edentulous | non-classified)	
	Community Periodontal Index (CPI; score 0, 1, or 2 | score 3 | score 4 | edentulous)†	
Plaque	Modified Marginal Plaque Index (mMPI; % segments with plaque)	
Molar-incisor hypomineralization (MIH)	MIH (yes | no)	
	Maximum degree of expression (no MIH | demarcated opacity | posteruptive enamel breakdown, circumscribed | posteruptive enamel breakdown, extensive | atypical restoration | extraction due to MIH)	
	Number of MIH teeth	
Erosions (BEWE)	Erosions (yes | no)	
	Maximum BEWE score (no erosion | initial loss of surface structures | clinically manifest defect, loss of tissue < 50% of the most severely affected tooth surface | clinically manifest defect, loss of tissue ≥ 50% of the most severely affected tooth surface)	
	Risk level classification (no increased risk level | slightly increased risk level | medium risk level | high risk level)	
Oral mucosa findings	Suspected:	Carcinoma (yes | no)
		Leukoplakia (yes | no)
		Oral lichen planus (yes | no)
		Smoker's keratosis (yes | no)
		Candida (yes | no)
		Prothesis-related changes (yes | no)
		Other (yes | no)
Dentures	Fixed dentures	Bridges (yes | no)
		Implants (yes | no)
		Number of implants*
	Removable dentures	Removable dentures* (yes | no; n)
		Acrylic partial dentures (yes | no; n)
		Cast framework partial dentures (yes | no; n)
		Combined fixed-removable dentures (yes | no; n)
		Hybrid dentures (yes | no; n)
		Complete dentures (yes | no; n)
	Wearing behavior (dentures are worn | dentures are not worn or only worn sporadically)	
	Removable denture quality (no deficiencies, very good quality | acceptable condition, good quality | moderate deficiencies, moderate quality | major deficiencies, poor quality)	
	Primary prosthetic treatment (fully dentate [no gaps, no dentures] | ≥ 1 untreated gap, no dentures | ≥ 1 one crown restoration | ≥ 1 fixed denture (ie, bridge/implant) | ≥ 1 removable partial denture | ≥ 1 complete denture)*	
Oral functional capacity	Resilience capacity level (normal | slightly reduced | greatly reduced | no resilience)	
	Therapeutic capability (normal | slightly reduced | greatly reduced | none)	
	Oral hygiene ability (normal | slightly reduced | greatly reduced | none)	
	Self-responsibility (normal | reduced | none)	

BEWE, Basic Erosive Wear Examination; CDC/AAP, Centers for Disease Control/American Academy of Periodontology; EFP/AAP, European Federation of Periodontology/American Academy of Periodontology.
*Variables calculated for the entire dentition and separately for the maxilla and mandible.
†Variables calculated for both full-mouth recording (28 teeth with 6 measurement sites each) and partial-mouth recording (12 index teeth with 3 measurement sites each).

and sugar consumption. Based on the quantitative variables collected, indices and transformed variables needed for data analysis were defined. An overview of the social science variables is provided in Tables 2 and 3.

The manual for the clinical examination, the social science questionnaires, and the documentation on the definition of transformed variables with details on processing quantitative variables are published elsewhere.[13] As a quality assurance measure, variable transformations were validated internally and externally. Data processing was conducted using SPSS Statistics for Windows, Version 26 (IBM) and R Version 4.4.1 (R Core Team).

Statistical methods

Study participants were included in the analysis set if they met all defined inclusion criteria:

- complete recording of dental findings
- complete recording of caries findings
- recording of periodontal findings in at least two quadrants.

In the 12-year-old age group, only the first two criteria were relevant. Missing information on the social science survey did not lead to exclusion from the analysis set. Depending on the research question, data analysis accounted for weighting factors, with primary use of modified design weights. Analyses were performed using SPSS Statistics for Windows, Version 26, R Version 4.4.1, and Stata/MP 18.0 (StataCorp).

Missing data

All three survey components – clinical examination, computer-assisted personal interview (CAPI), and paper and pencil interview (PAPI) – were completed by 95.2% of participants.

At least one interview was missing for 4.8% of cases (PAPI 4.7%, CAPI 0.7%). Additional missing data due to refusals or non-recordable data, lack of responses, or implausible entries varied between 0% and 12% across variables (item "missingness"). Missing data was uncommon for variables assessed during the clinical examination or CAPI (generally 0% to 1%). Variables captured through PAPI had the highest rates of missing data (2% to 12%). This corresponds to the request for sensitive personal information such as income in this survey mode. Missing values were not imputed. For epidemiologic description, available case analysis was used; for regression analyses, only cases with complete data on all variables considered were included (complete case analysis).

Characteristics of study participants

Descriptive analyses of social science variables were conducted to characterize study participants. For continuous variables, mean and standard deviation were given, and for categorical variables, absolute (n) and relative frequencies (in %) were provided. These analyses were based on unweighted data, the results were presented separately by age group.

Epidemiologic description

The epidemiologic description aimed to answer the first research question of DMS • 6: What are the current prevalence rates of oral diseases?

Prevalences and means with corresponding 95% confidence intervals (CIs) were calculated using a weighted dataset. Edentulous participants were included in the prevalence calculations to obtain population-representative prevalence data. Results were presented separately by age group for participants in the DMS • 6 cross-sectional component. Within age groups, further subgroup analysis was conducted based on variables of interest, such as self-reported gender (male/female), education group (low/medium/high), migration history (yes/no), and the presence of at least one cardiovascular disease (yes/no).

Association analyses

The association analyses sought to answer the second research question of DMS • 6: What associations exist between oral health and other participant characteristics?

Associations between oral health and various participant characteristics, such as education, migration history, smoking status, oral hygiene behavior, chronic diseases, and diet, were initially explored descriptively using cross-tabulations and bar charts (for two categorical variables), comparisons of measures of central tendency and dispersion along with box plots (for one categorical and one continuous variable), or correlation coefficients and scatter plots (for two continuous variables).

Mixed-effects regression models were fitted to estimate the extent of associations between explanatory variables of interest (exposures) and oral health-related outcomes. Generalized linear models with Gaussian or gamma distribution and Poisson regression with robust standard errors were used. Beginning with univariable models for the exposure variable, covariates such as age, gender, and education status were incorporated stepwise as fixed effects, while a composite regional variable was included as a random effect. The composite re-

Table 2 Overview of social science variables from the paper and pencil interview

Topic	Variable
Sociodemographics	Age (years)
	Gender (male | female | diverse)
	Body mass index (kg/m^2)
Socioeconomic status (SES)	SES-index (SES total score, SES sub-score Education, SES sub-score Occupation, SES sub-score Income)
	SES-group (low | medium | high)
	Education group (low | medium | high)
	School education (< 10 years | 10 years | > 10 years)
	Monthly net equivalent income (Euro)
	Subjective social status (low | medium | high)
Health economics	Health insurance status (statutory health insurance | statutory health insurance + supplementary health insurance | private health insurance | other | no health insurance)
	Need for dental or orthodontic examination or treatment in the last 12 months (yes | no)
	Refusal of dental examination or treatment due to cost in the last 12 months (yes | no)
	Refusal of orthodontic examination or treatment due to cost in the last 12 months (yes | no)
	Utilization of dental or orthodontic treatment in the last 12 months (yes | no)
	Out-of-pocket amount for dental or orthodontic treatment in the last 12 months (Euro)
Migration	Migration history (people with migration history | people without migration history)
	Immigration generation (1st generation: immigrated to Germany themselves | 2nd generation: both parents born outside Germany)
	Length of stay (years)
	Age at arrival (years)
	Language spoken at home (German | other | German + other)
	Self-assessment of German language skills (very good | good | moderate | limited | none)
	Residence status (German citizenship | permanent residence | temporary residence)
	Region of origin (Germany | Western Europe | Eastern Europe | North America, Australia, New Zealand | Central and South America | Asia | Africa | Turkey | Arab states)
Disability and need for care	Home care service utilization in the last 12 months (yes | no)
	Receipt of nursing care (yes | no)
	Level of care (level of care 1 | 2 | 3 | 4 | 5)
	Officially recognized disability (degree of disability < 50% | severe disability: degree of disability ≥ 50% | no)
Oral health-related quality of life (OHRQoL)	Oral Health Impact Profile (OHIP-G5 sum score)
Fluoride prophylaxis	Fluoride toothpaste use (yes | no)
	Fluoridated salt use (usually no | occasionally | usually yes)
Sugar consumption	Short form of the Marburg Sugar Index (MSI-S total score)
Dental anxiety	Modified Dental Anxiety Scale (mDAS sum score)

gional variable combined information on the region (North/East/South/West Germany) and community size (rural, urban, metropolitan area), which was used as a random effect in the models instead of study centers because the number of centers (n = 90) was too large for model estimation. The results from the models were presented as regression coefficients (b) for generalized linear models or prevalence ratios (PR) for Poisson regressions along with 95% CIs and *P* values.

For association analyses, unweighted data from all age groups, both from the DMS • 6 cross-sectional and DMS • 6 cohort components, were utilized. Age groups were pooled as appropriate based on the research question.

Table 3 Overview of social science variables from the computer-assisted personal interview

Topic	Variable		
Utilization of preventive dental services	Dental service utilization (control-oriented | complaint-oriented)		
	Dental visit frequency (only in case of problems | < once a year | ≥ once a year | ≥ once every 6 months)		
	Professional tooth cleaning utilization (yes | no | don't know)		
	Professional tooth cleaning frequency (never | usually no PTC | < once a year | ≥ once a year | ≥ once every 6 months)		
	Dental office loyalty (office switching almost every visit | occasional office switching | usually no office switching)		
	Use of bonus booklet (yes | no)		
Oral hygiene behavior	Type of toothbrush used (electric | manual | both | none)		
	Interdental cleaning (yes | no)		
	Interdental cleaning aids (dental floss | tooth sticks | interdental brushes | multiple | none)		
	Tooth brushing frequency (< once daily | once daily | 2 times daily | > 2 times daily)		
	Interdental cleaning frequency (never | < once a week | ≥ once a week | ≥ once daily)		
Medical geography	Means of transport to the dental office	On foot (mentioned | not mentioned)	
		By bicycle (mentioned | not mentioned)	
		By public transport (mentioned | not mentioned)	
		By private vehicle (mentioned | not mentioned)	
		Other (mentioned | not mentioned)	
	Duration to reach the dental office (≤ 10 min | ≤ 30 min | ≤ 60 min | ≤ 90 min | > 90 min)		
Cardiometabolic diseases‡	Diabetes mellitus	Diabetes mellitus (Type 1 diabetes | Type 2 diabetes | gestational diabetes | no diabetes)	
		Age of onset of diabetes (years)	
		Duration of diabetes (years)	
		Controlled diabetes (HbA1c < 7% | HbA1c ≥ 7%)	
		Diabetes treatment at first manifestation / currently (insulin only | oral medication or GLP-1 analogs only | combinations: insulin and oral medication | diet or other treatment or no treatment)	
		Complications of diabetes mellitus	Retinopathy (yes | no | don't know)
			Blindness (yes | no | don't know)
			Protein in urine (yes | no | don't know)
			Kidney failure (yes | no | don't know)
			Dialysis (yes | no | don't know)
			Neuropathy (yes | no | don't know)
			Amputation (yes | no | don't know)
			Diabetic foot (yes | no | don't know)
	Cardiovascular diseases	Myocardial infarction (yes | no | don't know)	
		Angina pectoris (yes | no | don't know)	
		Cardiac insufficiency (yes | no | don't know)	
		Cardiac arrhythmias (yes | no | don't know)	
		Intermittent claudication (yes | no | don't know)	
		Stroke (yes | no | don't know)	
		Hypertension (yes | no | don't know)	
		Elevated blood lipids/cholesterol levels (yes | no | don't know)	
Dental treatments	Lifetime periodontal treatment (yes | no | don't know)		
	Orthodontic treatment utilization (yes | no)		
Self-assessment of health status and health literacy	Self-assessment of general health status / oral health status (very poor | poor | moderate | good | very good)		
	Locus of control* (very much | much | some | little | none)		
	Health literacy† (never | rarely | sometimes | often | always)		
Health services research	Dental office located close enough to home (yes | no)		
	Scheduling difficulties with the dentist in the last 12 months (yes | no)		
Smoking behavior	Smoking status (daily smoker | occasional smoker | former smoker | never smoked)		
	Duration of smoking exposure (years)		
	Number of cigarettes smoked per day / per week		

HbA1c, glycated hemoglobin; PTC, professional tooth cleaning.
*How much can you do yourself to maintain or improve your dental health?
†How often do you need help from someone when reading instructions, patient information leaflets, or other written materials from your doctor or pharmacist?
‡Self-report on medical diagnoses.

Trend analyses

Trend analyses aimed to answer the third research question of DMS • 6: How has the oral health and care status in Germany developed from 1989 to 2023?

Based on the DMS • 6 cross-sectional component, as well as the previous studies DMS I/II to DMS V, a trend analysis was conducted to describe the temporal development of the oral health and care status in Germany. This included a comparative presentation of epidemiologic descriptions and the care of oral diseases. The results were presented separately by age groups. Trend analyses beyond those mentioned here are described in detail in the respective result articles. In analyzing and presenting the results, one focus was the methodologic differences among the studies, and these were thoroughly discussed. For instance, the examinations conducted as part of DMS I and II took place in dental practices, whereas, since DMS III, participants have been invited to mobile examination centers. Moreover, both the clinical examination protocols and social science surveys have been updated over the years to align with new scientific standards.

Sensitivity analyses

For the epidemiologic description, the modified design weight was primarily used to weight the dataset. As part of sensitivity analyses, the evaluations were repeated using the calibration weight. The analyses revealed no substantively relevant deviations in the estimation results. Any additional sensitivity analyses conducted are described in the respective results articles.

Conclusion

This article presents details of data handling and statistical analysis of the cross-sectional data from DMS • 6. Based on cross-sectional data, current prevalence estimates and trend analyses on the development of oral health and care status in Germany were conducted using representative data. Associations between oral health and further participant characteristics could thereby be examined.

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Disclosure

KK, DS, FZ, CO, and ARJ are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and the author of the manuscript. DS is jointly responsible for statistical data preparation and analysis. NFB is the former deputy principal investigator and responsible for the social science study setting. VP is the scientific advisor of DMS • 6, jointly responsible for statistical analyses, and a co-author of the manuscript. FZ is responsible for the social science analysis and a co-author of the manuscript. CO is project manager of the DMS • 6. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript.

References

1. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in der Bundesrepublik Deutschland. Ergebnisse des nationalen IDZ-Survey 1989. Cologne: Deutscher Ärzte-Verl., 1991.

2. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in Ostdeutschland. Ergebnisse des IDZ-Ergänzungssurvey 1992. Cologne: Deutscher Ärzte-Verl., 1993.

3. Micheelis W, Reich E (eds). Dritte Deutsche Mundgesundheitsstudie (DMS III). Ergebnisse, Trends und Problemanalysen auf der Grundlage bevölkerungsrepräsentativer Stichproben in Deutschland 1997. Cologne: Deutscher Ärzte-Verl., 1999.

4. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006.

5. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

6. World Health Organization. Oral health surveys: Basic methods (5th Edition). Geneva: World Health Organization, 2013.

7. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N. Methodology of the Sixth German Oral Health Study (DMS • 6) to survey tooth and jaw misalignment. J Orofac Orthop 2023;84(Suppl 1):10–18.

8. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N, Kirschneck C. Sechste Deutsche Mundgesundheitsstudie (DMS • 6). Zahn- und Kieferfehlstellungen bei Kindern. Cologne: IDZ, 2021.

9. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

10. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

11. Statistisches Bundesamt (Destatis). Bevölkerungsfortschreibung 2022, Status: 31 December 2022; 2022. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/_inhalt.html. Accessed 29 November 2024.

12. Statistisches Bundesamt (Destatis). Sonderauswertung Mikrozensus 2022; 2022. https://erhebungsportal.estatistik.de/Erhebungsportal/informationen/informationen-%C2%ADzum-mikrozensus-3629. Accessed 29 November 2024.

13. Institut der Deutschen Zahnarzte (IDZ). Ergebnisportal der Deutschen Mundgesundheitsstudie • 6; 2025. https://www.Deutsche-Mundgesundheitsstudie.de (available here: Studienüberblick/Methodik). Accessed 17 March 2025.

Kathrin Kuhr

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Dominic Sasunna Data manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Nicolas Frenzel Baudisch Senior Researcher, infas Institute for Applied Social Science, Bonn, Germany; until 2023: Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Vinay Pitchika Research Associate, Department of Conservative Dentistry and Periodontology, LMU Hospital, Munich, Germany

Fabian Zimmermann Senior Researcher, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Cristiana Ohm Project manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany. Email: dms6@idz.institute

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Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6)

A. Rainer Jordan*, Prof Dr med dent, MS/Hendrik Meyer-Lueckel*, Prof Dr med dent, MPH/Kathrin Kuhr, Dr rer medic/ Dominic Sasunna/Katrin Bekes, Prof Dr med dent, MME/Ulrich Schiffner, Prof Dr med dent

Objectives: One goal of the 6th German Oral Health Study (DMS • 6) was to survey the caries experience and care for caries in a representative cross-sectional study across Germany. **Method and materials:** Using almost the same methodology as the previous studies DMS III (1997) to V (2014), data were collected on caries experience (including dmft/DMFT, root caries) in the three standard World Health Organization age groups (12-year-olds, 35- to 44-year-olds, and 65- to 74-year-olds) as well as among 8- and 9-year-olds. **Results:** The caries experience expressed as dmft/DMFT in 8- and 9-year-olds was 1.4 teeth, 59.9% were caries-free; the DMFT among 12-year-olds was 0.5 teeth, with 77.6% caries-free. There was a significant decrease in caries-related restorations among 35- to 44-year-olds, with DMFT being 8.3 teeth. The group of 65- to 74-year-olds had a DMFT of 17.6 teeth, which was mainly due to higher tooth retention; 5.0% were edentulous. The prevalence of root caries was 13.8% among 35- to 44-year-olds and 59.1% among 65- to 74-year-olds. **Conclusions:** The various oral health measures taken over recent decades seem to continue to have a positive impact in terms of reduced caries experience. Nevertheless, it appears that the maximum has been reached among 12-year-olds; however, within this group there continues to be a strong polarization of dental caries in adolescents from families with a low education status and a comparatively high treatment need for the primary teeth. The social gradient in tooth decay and tooth loss extends over the entire life span. The DMS • 6 study, being representative of the oral epidemiology of the population, shows the sustainability of successful prevention measures for caries in all age groups and education groups in Germany. At the same time, social inequalities persist. From a socio-medical perspective, it would make sense to align future prevention strategies specifically to the lifeworld of groups and communities that have not yet been reached. *(Quintessence Int 2025;56(Suppl):S30–S39; doi: 10.3290/j.qi.b5986212)*

Keywords: cross-sectional studies, deciduous tooth, dental care, dental caries, dentists, DMS 6, root caries

With the First/Second German Oral Health Study (DMS I [West Germany]/DMS II [East Germany]) in 1989 and 1992, the Institute of German Dentists (Institut der Deutschen Zahnärzte, IDZ) laid the foundation for a representative socio-epidemiologic monitoring of oral health and dental care status.[1,2] The high caries rate in children was of particular interest; it initially extended beyond the risk teeth of the first four molars and was the reason for the introduction of group and individual prophylaxis measures in Germany.[1] Since DMS III (1997), a continuous decline in dental caries in 12-year-olds has been observed, remaining at a low level since DMS IV (2005).[3,4] For adults and seniors, significantly lower decayed, missing, and filled teeth (DMFT) values only appeared from the last DMS V (2014) onwards.[5] This was attributable to different DMFT components in the two groups. In adults, since 1997 this has been primarily due to the decline in restorations, from 11.7 to 8.6 teeth; in seniors 11.1 instead of the previous 17.6 missing teeth were found, but, in contrast to the adults, there was no clear trend for restorations. Due to the increase in dental maintenance in seniors, the prevalence of root caries increased compared to DMS III (1997).[3-5]

Therefore, one goal of the 6th German Oral Health Study (DMS • 6) was to survey the caries experience and oral health care in younger children (8- and 9-year-olds), younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds) in a representative cross-sectional study across Germany.

Method and materials

The general methodology of the study is presented in separate articles.[6-8] The DMS • 6 has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

The dental data on the younger children were collected as part of the earlier orthodontic module of DMS • 6.[9,10] The analyses included all children who satisfied the inclusion criteria for the analysis set of the orthodontics module and in whom dental and caries findings were comprehensively recorded.

For the other age groups, all participants who satisfied the inclusion criteria for DMS • 6 analyses were included. In total, data from 692 younger children, 958 younger adolescents, 927 younger adults, and 797 younger seniors was included in the analysis.

Measurement methods

Coronal caries experience

The recording of caries in younger children was done using the International Caries Detection and Assessment System (ICDAS)[11]; the results were then converted into the dmf/DMF index. Carious surfaces with an ICDAS code of 5 or higher were classified as DT. For the other age groups, only clear clinically observable caries lesions were recorded (as usual in the DMF index). They included all stages and the consequences of caries, including restorations or extractions due to caries. Single-tooth crowns were considered caries-related restorations, whereas crowns to anchor dentures were not. Active lesions (white spots) and inactive lesions (brown spots) were recorded seperately. If an approximal lesion shone through to the vestibular or oral (anterior tooth, lateral tooth) or occlusal tooth surface (lateral tooth), this was registered as caries. The primary carious surface was recorded each time; adjacent surfaces in the case of proximal lesions were only recorded if the defect extended beyond the marginal ridge. Restorations for other reasons, such as trauma or molar incisor hypomineralization (MIH), were not included in the caries experience. Filled surfaces with simultaneous caries were assessed as carious if dentin caries was present; at the filling margin this was recorded as secondary caries.

Root caries experience

Root caries was recorded separately for younger adults and younger seniors and was not included in the DMF index. A root surface was considered carious if cavity formation with or without softening was observed. A distinction was made between active lesions (rather yellowish, soft to leathery – root surface gave way when prodded with a periodontal probe) and inactive lesions (brown to black, hard – root surface did not give way when probed). If root caries or a restoration at the root of the tooth was a continuation from the crown of the tooth that did not extend more than 2 mm to the adjacent root area, no findings were recorded for the root.

Variables and statistical analysis

Coronal caries experience was expressed as DMF index. Caries-free (prevalence) was defined as DMFT = 0.[12,13] In the 8- and 9-year-olds, due to the mixed dentition, the caries experience was calculated as a combination of dmf (for primary teeth) and DMF index (for permanent teeth) according to the following rules: Missing anterior primary teeth (central and lateral incisors, canines) were scored as "not erupted" and were not counted as missing due to caries; missing primary molars, on the other hand, were counted as missing due to caries. The degree of restoration was calculated as a ratio (FT/FT + DT) × 100. The Significant Caries Index (SiC)[14] was calculated to determine the caries risk group in children. If the prevalence of caries experience was less than one third in the age group, the dynamic Significant Caries Index (dSiC) was given as the percentage of people with caries experience and their mean caries experience.[15] The calculation of the prevalence of root caries experience was a binary recording at the participant level, including inactive, active, and secondary lesions as well as fillings. In order to obtain population-representative prevalence data, edentulous study participants were included in the prevalence calculation. The Root Caries Index (RCI) was used to describe its extent.[16]

For the epidemiologic description of caries experience and care, prevalences and means with associated 95% confidence intervals (CIs) were calculated using a weighted dataset. The aim was to compensate for different probabilities in the selection of subjects and differences in gender, age, and region compared to the population in Germany by using the weighted dataset. Numbers (n) are provided without weighting. Detailed information on data handling and statistical methods is described previously.[8]

Table 1 Caries experience and care in younger children (8- and 9-year-olds)

Variable	Entire dentition
No. of participants (n)	692
Caries-free (prevalence, dmft/DMFT = 0)	59.9% (56.2; 63.5)
dmft/DMFT	1.4 (1.2; 1.6)
dt/DT	0.4 (0.3; 0.4)
mt/MT	0.3 (0.2; 0.3)
ft/FT	0.8 (0.7; 0.9)
Increased caries risk (DAJ) (%)	4.2 (2.9; 5.9)
SiC	4.1 (3.8; 4.4)
dSiC	40.1%; 3.5 (3.2; 3.8)
Degree of restoration of coronal caries (%)	71.6 (66.8; 76.3)
Participants in need of treatment (prevalence, DT > 0)	16.0% (13.4; 18.8)
Primary teeth crowns (prevalence)	2.8% (1.7; 4.1)
No. of primary teeth crowns, if ≥ 1 primary tooth crown	1.4 (1.0; 1.9)

Data are presented as unweighted numbers (n) and weighted percentages or weighted means (with 95% confidence intervals) for younger children with valid information on dmft/DMFT. Indexes written in lowercase letters refer to the primary dentition.
DAJ, Deutsche Arbeitsgemeinschaft für Jugendzahnpflege e. V. (German Working Group for Adolescent Dental Care); DMFT, decayed, missing, filled teeth; dSiC, dynamic SiC (percentage of persons with caries experience; their mean caries experience); DT, decayed teeth; FT, filled teeth; MT, missing teeth; SiC, Significant Caries Index.

Results

Caries experience and care in younger children (8- and 9-year-olds)

The entire dentition was free of caries in 59.9% of younger children. The mean caries experience was 1.4 teeth (dmft 1.3; DMFT 0.1); of these, 0.4 teeth were carious (dt 0.3; DT 0.0), 0.3 were missing due to caries (mt 0.2; MT 0.0), and 0.8 teeth had restorations (ft 0.7; FT 0.1). In total, 2.8% of younger children had primary tooth crowns. An increased caries risk as defined by the criteria of the German Working Group for Adolescent Dentistry (DAJ: dmft/DMFT > 7 or DT > 2) was found in 4.2% of younger children. The SiC was 4.1 teeth. The degree of restoration was 71.6%, and 16.0% of younger children required treatment. For caries-free status, caries experience, and increased caries risk, a gradient was found along the family education status (Table 1 and Appendix 1).

Caries experience and care in younger adolescents (12-year-olds)

The entire dentition was free of caries in 77.6% of younger adolescents. The mean caries experience in younger adolescents was 0.5 DMF teeth; of these, 0.2 teeth were carious and 0.4 teeth had restorations. Tooth loss due to caries was almost nonexistent in this age group. Younger adolescents had an average of 0.5 teeth with active initial lesions. An increased caries risk as defined by the criteria of the DAJ showed 3.3% with DT on at least one approximal surface.[17] The dSiC was 2.4 teeth for 22.4% of younger adolescents. Fissure sealings were observed in 59.5%, and younger adolescents with fissure sealings had an average of 4.6 sealed teeth. The degree of restoration was 71.6%, and 8.4% of younger adolescents required treatment. For caries experience and the number of carious teeth, there was a clear gradient along the family education status: caries experience was four times higher in adolescents with a low family education status than in adolescents with a high family education status (Tables 2 and 3).

Caries experience and care in younger adults (35- to 44-year-olds)

The mean caries experience in younger adults was 8.3 DMF teeth; of these, 0.5 teeth were carious, 1.0 teeth were missing due to caries, and 6.8 teeth had restorations. Younger adults were free of caries in 6.9% of cases, and complete edentulism was practically nonexistent in this age group (0.1%). Fissure sealing was observed in 13.8% of younger adults. The degree of restoration for coronal caries was 92.3%, and 21.9% of younger adults required treatment. In total, 26.1 teeth were sound or filled (FST index). Approximately one in seven younger adults had root caries (13.8%), the affected proportion of exposed root surfaces (RCI) was 8.3%, and the associated degree of restoration was 67.9% (Table 2).

For caries-free status, caries experience, tooth loss, and degree of rehabilitation of the root caries, there was a (sometimes strong) gradient along the education status (Table 3).

Caries experience and care in younger seniors (65- to 74-year-olds)

In total, 5.0% of younger seniors were edentulous. The mean caries experience was 17.6 DMF teeth; of these, 0.4 teeth were carious, 8.6 teeth were missing due to caries, and another 8.6 teeth had restorations. There were no caries-free people in the group of 65- to 74-year-olds. The degree of restoration of

Table 2 Caries experience and care in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds)

Variable	12-year-olds	35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)	958	927	797
Edentulism (prevalence)	0.0% (NA)	0.1% (0.0; 0.5)	5.0% (3.7; 6.7)
Caries-free (prevalence, DMFT = 0)	77.6% (74.8; 80.1)	6.9% (5.4; 8.7)	0.0% (NA)
No. of teeth with active initial lesions	0.5 (0.4; 0.6)	1.2 (1.0; 1.3)	0.2 (0.1; 0.2)
Caries experience (prevalence, DMFT > 0)	22.4% (19.9; 25.1)	93.1% (91.3; 94.6)	100.0% (NA)
DMFT = 0 + active initial lesions = 0 (prevalence)	68.9% (65.9; 71.8)	5.4% (4.1; 7.0)	0.0% (NA)
Fissure sealing (prevalence)	59.5% (56.4; 62.6)	13.8% (11.7; 16.1)	NA
No. of sealed teeth if ≥ 1 sealed tooth	4.6 (4.3; 4.8)	3.6 (3.1; 4.2)	NA
DMFT	0.5 (0.5; 0.6)	8.3 (8.0; 8.7)	17.6 (17.2; 18.0)
DT	0.2 (0.1; 0.2)	0.5 (0.4; 0.6)	0.4 (0.3; 0.5)
MT	0.0 (0.0; 0.0)	1.0 (0.9; 1.2)	8.6 (8.0; 9.2)
FT	0.4 (0.3; 0.4)	6.8 (6.5; 7.1)	8.6 (8.2; 9.0)
FST	24.6 (24.4; 24.9)	26.1 (25.9; 26.3)	18.8 (18.2; 19.4)
ST	24.3 (24.0; 24.5)	19.3 (18.9; 19.6)	10.2 (9.8; 10.6)
Increased caries risk (DAJ) (%)	3.3 (2.3; 4.6)	NA	NA
SiC	1.5 (1.3; 1.7)	NA	NA
dSiC	22.4%; 2.4 (2.2; 2.6)	NA	NA
DMFS	0.8 (0.7; 0.9)	21.7 (20.4; 23.0)	69.9 (67.8; 71.9)
DS	0.2 (0.1; 0.3)	0.9 (0.7; 1.1)	0.8 (0.6; 1.0)
MS	0.1 (0.0; 0.1)	4.9 (4.2; 5.6)	40.7 (38.1; 43.3)
FS	0.5 (0.4; 0.6)	15.9 (15.0; 16.8)	28.4 (26.9; 29.8)
Root caries (prevalence)	NA	13.8% (11.7; 16.1)	59.1% (55.7; 62.5)
No. of teeth with active root or secondary lesions	NA	0.1 (0.0; 0.1)	0.4 (0.3; 0.4)
No. of teeth with filled root surfaces	NA	0.2 (0.1; 0.3)	1.5 (1.3; 1.7)
Root Caries Index (%)	NA	8.3 (6.7; 9.9)	20.4 (18.4; 22.3)
Degree of restoration of coronal caries (%)	71.6 (66.1; 77.1)	92.3 (91.0; 93.6)	92.9 (91.4; 94.3)
Participants in need of treatment (prevalence, DT > 0)	8.4% (6.8; 10.3)	21.9% (19.3; 24.6)	20.0% (17.4; 23.0)
Degree of restoration of root caries* (%)	NA	67.9 (58.6; 77.1)	76.9 (73.3; 80.6)

Data are presented as unweighted numbers (n) and weighted percentages or weighted means (with 95% confidence intervals).
*The degree of restoration of root caries (%) was calculated as follows: (no. of teeth with filled root surfaces / (no. of teeth with filled root surfaces + no. of teeth with active root or secondary lesions)) × 100.
DMFS, decayed, missing, filled tooth surfaces; DMFT, decayed, missing, filled teeth; DS, carious tooth surfaces; dSiC, dynamic SiC (percentage of persons with caries experience; their mean caries experience); DT, decayed teeth; FS, filled tooth surfaces; FST, filled or sound teeth; FT, filled teeth; MS, missing tooth surfaces; MT, missing teeth; NA, not available; SiC, Significant Caries Index; ST, sound teeth.

coronal caries was 92.9%, and 20.0% of the study participants required treatment. The FST index was 18.8 teeth. Over half of people aged 65 to 74 had root caries (59.1%), the affected proportion of exposed root surfaces (RCI) was 20.4%, and the associated degree of restoration was 76.9% (Table 2).

For complete edentulism (low education status 8.8%, vs high education status 1.9%) and for tooth loss (MT; low education status 11.3 teeth, vs high education status 5.5 teeth) there was a clear social gradient. This was also reflected in caries experience (DMFT) and the FST index (Table 3).

Table 3 Caries experience and care in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds), by gender and education group

		Gender		Education group		
Age group	Variable	Male	Female	Low	Medium	High
12-year-olds	No. of participants (n)	484	473	84	420	383
	Caries-free (prevalence, DMFT = 0)	76.7% (72.8; 80.3)	78.5% (74.5; 82.0)	59.0% (48.3; 67.8)	74.3% (69.8; 78.3)	84.7% (80.7; 87.9)
	No. of teeth with active initial lesions	0.5 (0.3; 0.6)	0.5 (0.3; 0.7)	1.0 (0.5; 1.5)	0.6 (0.4; 0.8)	0.3 (0.2; 0.4)
	DMFT = 0 + active initial lesions = 0 (prevalence)	68.4% (64.3; 72.4)	69.4% (64.9; 73.4)	49.5% (39.1; 58.9)	64.9% (60.1; 69.4)	76.2% (71.7; 80.2)
	Fissure sealing (prevalence)	55.8% (51.4; 60.1)	63.3% (58.7; 67.5)	51.0% (41.1; 60.9)	61.7% (56.9; 66.3)	60.5% (55.5; 65.3)
	No. of sealed teeth if ≥ 1 sealed tooth	4.3 (4.0; 4.5)	4.9 (4.5; 5.2)	3.1 (2.6; 3.7)	4.6 (4.3; 5.0)	4.8 (4.4; 5.2)
	DMFT	0.6 (0.5; 0.7)	0.5 (0.4; 0.6)	1.2 (0.8; 1.6)	0.6 (0.5; 0.7)	0.3 (0.2; 0.4)
	DT	0.2 (0.1; 0.2)	0.1 (0.1; 0.2)	0.4 (0.2; 0.6)	0.2 (0.1; 0.2)	0.1 (0.0; 0.1)
	MT	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
	FT	0.4 (0.30; 0.5)	0.4 (0.3; 0.5)	0.8 (0.5; 1.1)	0.4 (0.3; 0.5)	0.2 (0.2; 0.3)
	Degree of restoration of coronal caries (%)	70.6 (63.0; 78.1)	72.9 (64.7; 81.1)	62.0 (47.5; 76.4)	73.2 (65.3; 81.0)	76.0 (65.8; 86.2)
35- to 44-year-olds	No. of participants (n)	459	467	80	408	383
	Edentulism (prevalence)	0.1% (0.0; 1.0)	0.0% (0.0; 0.0)	0.7% (0.1; 5.4)	0.0% (0.0; 0.0)	0.0% (0.0; 0.0)
	Caries-free (prevalence, DMFT = 0)	7.8% (5.6; 10.5)	6.1% (4.2; 8.5)	0.4% (0.0; 2.9)	5.8% (3.8; 8.3)	10.2% (7.5; 13.7)
	No. of teeth with active initial lesions	1.1 (0.9; 1.3)	1.2 (1.0; 1.4)	1.4 (0.8; 1.9)	1.3 (1.0; 1.5)	1.1 (0.9; 1.3)
	DMFT = 0 + active initial lesions = 0 (prevalence)	5.9% (4.1; 8.5)	4.9% (3.2; 7.1)	0.4% (0.0; 2.9)	4.8% (3.0; 7.1)	7.6% (5.3; 10.7)
	DMFT	7.9 (7.4; 8.4)	8.7 (8.2; 9.2)	11.4 (10.1; 12.8)	8.8 (8.3; 9.3)	7.0 (6.5; 7.6)
	DT	0.6 (0.5; 0.7)	0.5 (0.3; 0.6)	1.2 (0.8; 1.6)	0.4 (0.3; 0.5)	0.4 (0.2; 0.5)
	MT	1.1 (0.8; 1.3)	1.0 (0.8; 1.2)	3.1 (2.1; 4.2)	1.1 (0.9; 1.3)	0.4 (0.3; 0.5)
	FT	6.3 (5.9; 6.7)	7.3 (6.8; 7.7)	7.1 (6.0; 8.2)	7.3 (6.8; 7.7)	6.3 (5.8; 6.7)
	FST	26.0 (25.7; 26.3)	26.1 (25.9; 26.4)	23.5 (22.4; 24.6)	26.1 (25.8; 26.3)	26.8 (26.6; 27.0)
	ST	19.7 (19.2; 20.2)	18.9 (18.4; 19.4)	16.4 (15.1; 17.8)	18.8 (18.3; 19.3)	20.5 (20.0; 21.0)
	Root caries (prevalence)	15.7% (12.6; 19.4)	12.0% (9.3; 15.2)	14.9% (8.9; 24.0)	14.4% (11.3; 18.1)	12.0% (9.1;15.7)
	No. of teeth with active root or secondary lesions	0.1 (0.0; 0.3)	0.0 (0.0; 0.1)	0.1 (0.0; 0.3)	0.1 (0.0; 0.1)	0.1 (0.0; 0.2)
	No. of teeth with filled root surfaces	0.2 (0.1; 0.3)	0.2 (0.1; 0.3)	0.2 (0;0; 0.6)	0.2 (0.1; 0.3)	0.2 (0.1; 0.3)
	Root Caries Index (%)	10.0 (7.5; 12.5)	6.5 (4.5; 8.6)	16.5 (7.1; 25.9)	9.2 (6.6; 11.8)	6.2 (4.1; 8.3)
	Degree of restoration of coronal caries (%)	90.4 (88.2; 92.5)	94.1 (92.6; 95.6)	80.3 (73.4; 87.1)	94.1 (92.5; 95.8)	94.5 (92.8; 96.1)
	Degree of restoration of root caries* (%)	65.5 (52.9; 78.2)	70.8 (56.7; 84.8)	45.6 (8.8; 82.5)	71.6 (58.4; 84.7)	83.3 (70.3; 96.3)
65- to 74-year-olds	No. of participants (n)	375	422	158	367	230
	Edentulism (prevalence)	6.4% (4.3; 9.2)	3.8% (2.2; 5.8)	8.8% (5.4; 13.6)	5.0% (3.0; 7.5)	1.9% (0.6; 4.2)
	DMFT	17.4 (16.8; 18.0)	17.9 (17.3; 18.4)	18.7 (17.8; 19.6)	17.6 (17.0; 18.2)	16.9 (16.3; 17.5)
	DT	0.5 (0.3; 0.7)	0.3 (0.3; 0.4)	0.5 (0.3; 0.7)	0.4 (0.3; 0.5)	0.4 (0.2; 0.6)
	MT	8.7 (7.8; 9.5)	8.5 (7.7; 9.3)	11.3 (10.0; 12.7)	9.0 (8.2; 9.9)	5.5 (4.6; 6.3)
	FT	8.2 (7.7; 8.8)	9.0 (8.5; 9.6)	6.9 (6.1; 7.7)	8.2 (7.6; 8.8)	11.0 (10.3; 11.7)
	FST	18.7 (17.8; 19.5)	19.0 (18.2; 19.7)	16.0 (14.7; 17.4)	18.5 (17.6; 19.3)	22.0 (21.1; 22.8)
	ST	10.4 (9.9; 11.0)	9.9 (9.4; 10.4)	9.1 (8.2; 10.0)	10.2 (9.7; 10.8)	10.9 (10.3; 11.5)
	Root caries (prevalence)	61.2% (56.2; 65.8)	57.1% (52.1; 61.7)	56.9% (49.6; 64.0)	56.5% (51.3; 61.7)	64.2% (57.8; 70.4)
	No. of teeth with active root or secondary lesions	0.5 (0.3; 0.6)	0.3 (0.2; 0.3)	0.3 (0.2; 0.4)	0.3 (0.2; 0.4)	0.4 (0.2; 0.6)
	No. of teeth with filled root surfaces	1.6 (1.3; 1.9)	1.4 (1.2; 1.7)	1.4 (1.0; 1.8)	1.5 (1.2; 1.8)	1.6 (1.3; 2.0)
	Root Caries Index (%)	20.8 (18.0; 23.6)	20.0 (17.3; 22.6)	20.4 (16.4; 24.5)	21.1 (18.1; 24.2)	18.5 (15.2; 21.7)
	Degree of restoration of coronal caries (%)	91.3 (89.0; 93.7)	94.3 (92.6; 96.0)	90.2 (86.3; 94.1)	93.9 (92.1; 95.7)	95.9 (94.0; 97.7)
	Degree of restoration of root caries* (%)	73.3 (67.9; 78.7)	80.8 (75.9; 85.7)	78.1 (70.3; 85.9)	76.4 (70.7; 82.1)	79.6 (73.1; 86.1)

Data are presented as unweighted numbers (n) and weighted precentages or weighted means (with 95% confidence intervals).
*The degree of restoration of root caries (%) was calculated as follows: (no. of teeth with filled root surfaces / (no. of teeth with filled root surfaces + no. of teeth with active root or secondary lesions)) × 100.
DMFT, decayed, missing, filled teeth; DT, decayed teeth; FST, filled or sound teeth; FT, filled teeth; MT, missing teeth; ST, sound teeth.
Two gender-diverse individuals are included in the education groups, but not in the gender categories.

Discussion

At the end of the 1980s, the introduction of individual and group prophylaxis for children and adolescents in Germany laid the foundation for a paradigm shift from reparative to preventive dental health care. The results have been impressive: since the introduction of these measures, caries experience has declined to one tenth of its initial level (DMFT 12-year-olds DMS I/II, 4.9 teeth, vs DMS • 6, 0.5 teeth) (Table 4). The decline in caries in children is a prime example of how socio-medical measures can address a significant health burden within the population. What was uncertain so far was the sustainability of these health improvements over a lifespan.

In the DMS V of 2014, the age group of younger adults (35- to 44-year-olds) was the first time that people who had benefited – at least partially – from individual and group prophylaxis in their childhood were included in a German Oral Health Study; the younger adults in the current survey were the first to fully benefit from these measures and have grown up in this prevention-oriented mindset. During this period, the caries burden in younger adults has halved from 16.9 teeth to 8.3 teeth, and the proportion of caries-free people in the population has risen from 0.4% to 6.9%. This caries decline is primarily due to fewer restorations (FT, DMS III [1997]: 11.7 teeth, vs DMS • 6 [2023]: 6.8). In particular, the decline in caries-related restorations among younger adults since 2005 is an indication of the sustained effectiveness of prevention not just in studies but under everyday conditions.

A focus on prevention with the aim of lifelong tooth retention, and developments in health technology, have also led to a sharp decline in tooth loss in the overall population. This is visible very clearly in the development of complete edentulism. While in 1997, a quarter of 65- to 74-year-olds were edentulous, today the figure is only 5%. Tooth loss in general is also in decline in all age groups (1997 to 2023, 35- to 44-year-olds: −4.6 teeth; 65- to 74-year-olds: −9.0 teeth) and is responsible for the declining caries experience, especially among younger seniors.

However, the positive caries epidemiologic developments are offset by a pronounced social gradient along the education status. Even in younger adolescents, it should be noted that both the number of (untreated) carious teeth and the caries experience as a whole is four times higher in adolescents with a low family education status than in those with a high family education status. This imbalance extends over the entire lifespan, up to complete edentulism in 65- to 74-year-olds, with a difference factor of 4.6 in that group. However, epidemiologic data must be viewed in a differentiated manner, as a comparison of the caries-related health gains among 12-year-olds according to different endpoints reveals contrasting developments with regard to the social gradient. On the one hand, 12-year-olds with a low family education status have experienced relatively fewer health gains in caries experience than those with a high family education status (DMFT; low education status: DMS I/II 5.8 teeth, DMS • 6 1.2, decline by a factor of 5 vs high education status: DMS I/II 3.1 teeth, DMS • 6 0.3, decline by a factor of 10). On the other hand, adolescents with a low family education status have experienced relatively more health gains in terms of caries-free status (DMFT = 0; low education status: DMS I/II 8.6%, DMS • 6 59.0%, increase by a factor of 6.9 vs high education status: DMS I/II 24.2%, DMS • 6 84.7%, increase by a factor of 3.5).

One strength of DMS • 6 is that, in addition to the cross-sectional oral epidemiologic study and social science survey to determine disease prevalence and behavior, study participants from the previous study DMS V were also examined again, so that disease progression and incidence can be reported. Cause–effect relationships with risk factors can also be better identified in this way. These results will be published in spring 2026. A further strength that can be noted is that since the First/Second German Oral Health Study in 1989/1991, younger children in the mixed dentition phase were examined for the first time, making it possible to make population-wide statements on primary tooth decay.

Some of the difficulties of the globally used index for recording caries experience (DMF index) should be noted. There are various reasons for these:

- In epidemiologic studies, it is hardly possible to identify the actual causes of tooth loss. However, the index is intended to consider only tooth loss due to caries. Studies show that the main cause for tooth loss from the age of around 40 is periodontal disease.[18] It should therefore be assumed that the M component of the DMF index overestimates the caries experience. Although different causes for missing teeth are identified in dental care, sensitivity analyses show only minor differences in the M component when including teeth explicitly recorded as missing due to caries (procedure in the DMS • 6) compared to the calculation including all missing teeth (procedure in the DMS V).
- By definition, single tooth crowns belong in the F component of the DMF index, because it is assumed that these crowns were placed due to caries, while anchor crowns (to anchor dentures) were not. The extent to which this principle still corresponds to today's treatment realities, eg, as a result of implants, which did not exist when the index was first described in 1938, requires critical examination. Sensitivity

Table 4 Trends of caries experience and care in younger children (8- and 9-year-olds), younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds) from DMS I/II to DMS • 6

Age group	Variable	DMS I/II	DMS III	DMS IV	DMS V	DMS • 6
8- and 9-year-olds (entire dentition)	No. of participants (n)	825	NA	NA	NA	692
	Caries-free (prevalence, dmft/DMFT = 0)	21.1%	NA	NA	NA	59.9%
	dft/DFT†	4.4	NA	NA	NA	1.1
	dt/DT	2.3	NA	NA	NA	0.4
	ft/FT	2.2	NA	NA	NA	0.8
12-year-olds	No. of participants (n)	848*	1,043	1,383	1,468	958
	Caries-free (prevalence, DMFT = 0)	13.8%*	41.8%	70.1%	81.3%	77.6%
	Fissure sealing (prevalence)	NA	52.9%	71.7%	70.3%	59.5%
	Number of sealed teeth if ≥ 1 sealed tooth	NA	1.9	3.7	4.0	4.6
	DMFT	4.9*	1.7	0.7	0.5	0.5
	DT	1.8*	0.4	0.2	0.1	0.2
	MT	0.1*	0.0	0.0	0.1	0.0
	FT	3.1*	1.3	0.5	0.3	0.4
	Degree of restoration of coronal caries (%)	65.3*	79.5	78.1	74.6	71.6
35- to 44-year-olds	No. of participants (n)	815	655	925	966	927
	Edentulism (prevalence, DMFT = 0)	1.2%	1.1%	1.0%	0.8%	0.1%
	Caries-free (prevalence)	0.4%	0.8%	0.7%	2.5%	6.9%
	DMFT	16.9	16.1	14.5	11.2	8.3
	DT	1.7	0.5	0.5	0.5	0.5
	MT	5.6	3.9	2.4	2.1	1.0
	FT	9.6	11.7	11.7	8.6	6.8
	FST	NA	23.6	25.2	25.4	26.1
	ST	NA	11.9	13.5	16.8	19.3
	Root caries (prevalence)	NA	22.1%	21.5%	11.8%	13.8%
	Degree of restoration of coronal caries (%)	83.0	92.5	95.6	93.7	92.3
65- to 74-year-olds	No. of participants (n)	NA	1,367	1,040	1,042	797
	Edentulism (prevalence)	NA	24.8%	22.6%	12.4%	5.0%
	Caries-free (prevalence, DMFT = 0)	NA	0.3%	0.1%	0.1%	0.0%
	DMFT	NA	23.6	22.1	17.7	17.6
	DT	NA	0.3	0.3	0.5	0.4
	MT	NA	17.6	14.1	11.1	8.6
	FT	NA	5.8	7.7	6.1	8.6
	FST	NA	10.2	13.6	16.4	18.8
	ST	NA	4.4	5.9	10.3	10.2
	Root caries (prevalence)	NA	15.5%	45.0%	28.0%	59.1%
	Degree of restoration of coronal caries (%)	NA	93.2	94.8	90.6	92.9

Data are presented as unweighted numbers (n) and weighted percentages or weighted means.
*13- and 14-year-olds.
†Caries experience of 8- and 9-year-olds without missing teeth, as collection in the different surveys is not comparable.
DMFT, decayed, missing, filled teeth; DT, decayed teeth; FST, filled or sound teeth; FT, filled teeth; MT, missing teeth; NA, not available; ST, sound teeth.

analyses have shown that including anchor crowns increases the F component by half a tooth in younger adults and by 2.5 teeth in younger seniors. Based on these calculations, it can be assumed that the failure to record anchor crowns in the F component of the DMF index tends to underestimate the number of restorations. This assumption can be further substantiated by the fact that it can be assumed that modern tooth-colored restorations are also less easily spotted under field conditions of oral epidemiologic examinations (compared to easily recognizable amalgam fillings, for example).

- Finally, the DMF index can only increase across the lifespan; as an overall index, it does not reflect the dental care status, as from a functional perspective it makes a difference whether carious teeth have already been lost or have been functionally restored through restorations. For this reason, in 1987 Sheiham et al[19] developed the FST index, which combines filled (FT) and sound (ST) teeth. In the current study, younger adults had 26.1 sound and functional teeth (+2.5 teeth since 1997), and younger seniors had 18.8 teeth (+8.6 teeth since 1997). There has therefore been a significant increase in caries-related functionality, especially later in life.

For a national comparison, regional data on caries experience are available from the Study of Health in Pomerania (SHIP-Trend-0)[20] from 2008 to 2012. In this study, 35- to 44-year-olds had 7.8 teeth with caries experience and 65- to 74-year-olds had 11.3 teeth. Edentulism among younger seniors amounted to 15.1%. The mean caries experience was lower than the national average in both age groups, but the proportion of edentulism was significantly higher among younger seniors. In addition to methodologic variations in the definition of the DMF index, regional (care) differences could explain the discrepancies. For younger adolescents, data are available from the epidemiologic companion study on group prophylaxis from 2016.[21,22] In that study, 78.8% (DMS • 6: 77.6%) of 12-year-olds were caries-free and the mean caries experience was 0.44 (DMS • 6: 0.5) teeth. The dSiC was 2.1 teeth (DMS • 6: 2.4 teeth) in 21.2% (DMS • 6: 22.4%) of adolescents with DMFT > 0. Besides potential differences in how the findings are made and a temporal effect, the results appear comparable and could be an indication that the peak of the prevention potential has been achieved with the efforts deployed to date. It should, however, be noted that for organizational reasons, the younger adolescents in the DMS • 6 were on average slightly older than the age group of the same assignment in the DMS V. It is therefore possible that the true mean value of caries experience for 12-year-olds is currently somewhat lower.

In Europe, caries prevalence (dmft or DMFT > 0) in primary teeth is 21.4%[23] (DMS • 6: 38.7%) and in the permanent teeth of 12-year-olds is 44.1% (DMS • 6: 22.4%).[24] This confirms that the caries experience of 12-year-olds in Germany is comparatively low, but that the success of the prevention strategies has not yet been reproduced in primary teeth. As a result, in 2019 new early detection measures (and new billing items) for early childhood caries were included in the statutory health insurance. However, it should be noted that the data reported here do not yet reflect these new measures. Data comparing caries and edentulism in adults and seniors based on regional and national oral epidemiologic studies show for European comparison countries that both caries and edentulism in adults and seniors in Germany were already comparatively low before the current survey.[25] This classification is likely to have been reinforced with the now documented effectiveness of prevention orientation in all age groups.

Conclusion

The DMS • 6 study, being representative for the population in Germany, shows the sustainability of successful prevention measures for caries in all age groups and education groups in Germany. At the same time, social inequalities persist. From a socio-medical perspective, it would make sense to align future prevention strategies specifically to the lifeworld of groups and communities that have not yet been reached.

Disclosure

ARJ, KK, and DS are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have made a sufficient contribution to meet the criteria for authorship according to the ICMJE guidelines. They have all read and approved the final manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and author of the manuscript. HML is a member of the scientific advisory board of the DMS • 6, responsible for developing the clinical examina-

tions, and author of the manuscript. KK is the deputy pricipal investigator, responsible for the data analysis, and co-author of the manuscript. DS is jointly responsible for statistical data preparation and analysis. KB and US are members of the scientific advisory board of the DMS • 6, responsible for developing the clinical examinations, and co-authors of the manuscript.

References

1. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in der Bundesrepublik Deutschland. Ergebnisse des nationalen IDZ-Survey 1989. Cologne: Deutscher Ärzte-Verl., 1991.

2. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in Ostdeutschland. Ergebnisse des IDZ-Ergänzungssurvey 1992. Cologne: Deutscher Ärzte-Verl., 1993.

3. Micheelis W, Reich E (eds). Dritte Deutsche Mundgesundheitsstudie (DMS III). Ergebnisse, Trends und Problemanalysen auf der Grundlage bevölkerungsrepräsentativer Stichproben in Deutschland 1997. Cologne: Deutscher Ärzte-Verl., 1999.

4. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte-Verl., 2006.

5. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte-Verl., 2016.

6. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

7. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

8. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

9. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N, Kirschneck C. Sechste Deutsche Mundgesundheitsstudie (DMS • 6): Zahn- und Kieferfehlstellungen bei Kindern. Cologne: Institut der Deutschen Zahnärzte (IDZ), 2021.

10. Jordan AR, Kuhr K, Ohm C, Frenzel Baudisch N. Methodology of the Sixth German Oral Health Study (DMS • 6) to survey tooth and jaw misalignment. J Orofac Orthop 2023;84(Suppl 1):10–18.

11. Pitts N. "ICDAS" – an international System for caries detection and assessment being developed to facilitate caries epidemiology, research and appropriate clinical management. Community Dent Health 2004;21:193–198.

12. Klein H, Palmer CE, Knutson JW. Studies on dental caries: I. Dental status and dental needs of elementary school children. Public Health Reports 1938;53:751.

13. World Health Organization. Oral health surveys: Basic methods (5th Edition). Geneva: World Health Organization, 2013.

14. Bratthall D. Introducing the Significant Caries Index together with a proposal for a new global oral health goal for 12-year-olds. Int Dent J 2000;50:378–384.

15. Jordan AR, Micheelis W, Schmidt P, Zimmer S, Klingenberger D. Proposing the dynamic Significant Caries (dSiC) Index for low-caries populations [Abstract]. J Dent Res 2015;Spec Iss 94:2839.

16. Katz RV, Hazen SP, Chilton NW, Mumma RD. Prevalence and intraoral distribution of root caries in an adult population. Caries Res 1982;16:265–271.

17. Deutsche Arbeitsgemeinschaft für Jugendzahnpflege. Empfehlungen der Deutschen Arbeitsgemeinschaft für Jugendzahnpflege e. V. zur Weiterentwicklung der Gruppenprophylaxe. DAJ members assembly resolution from 19/06/2020. Bonn: DAJ, 2020.

18. Glockmann E, Panzner K-D, Huhn P, Sigusch BW, Glockmann K. Ursachen des Zahnverlustes in Deutschland. Dokumentation einer bundesweiten Erhebung (2007). Cologne: Institut der Deutschen Zahnärzte (IDZ), 2011 (IDZ-Information 2/2011).

19. Sheiham A, Maizels J, Maizels A. New composite indicators of dental health. Community Dent Health 1987;4:407–414.

20. Schmoeckel J, Abdul Haq J, Samietz S, et al. Ten-year trends in DMF-S and DMF-T in a northeast German adult population. J Dent 2021;111:103727.

21. Basner R, Santamaría RM, Schmoeckel J, Schüler E, Splieth CH, Deutsche Arbeitsgemeinschaft für Jugendzahnpflege. Epidemiologische Begleituntersuchungen zur Gruppenprophylaxe 2016. Bonn: DAJ, 2017.

22. Splieth CH, Schüler E, Santamaríia RM, Basner R, Schmoeckel J. Mehr Prävention im Milchgebiss! Zur Rolle von Gruppen-, Individual- und Kollektivprophylaxe. Zahnärztl Mitt 2018;108:662–667.

23. Kazeminia M, Abdi A, Shohaimi S, et al. Dental caries in primary and permanent teeth in children's worldwide, 1995 to 2019: a systematic review and meta-analysis. Head Face Med 2020;16:1–21.

24. Vukovic A, Schmutz KA, Borg-Bartolo R, et al. Caries status in 12-year-old children, geographical location and socioeconomic conditions across European countries: A systematic review and meta-analysis. Int J Paediatr Dent 2025;35:201–215.

25. Carvalho JC, Schiffner U. Dental caries in European adults and senior citizens 1996-2016: ORCA Saturday Afternoon Symposium in Greifswald, Germany - Part II. Caries Res 2019;53:242–252.

A. Rainer Jordan **Hendrik Meyer-Lueckel**

A. Rainer Jordan* Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Hendrik Meyer-Lueckel* Head, Department for Operative, Preventive and Pediatric Dentistry, Executive Director of the zmk bern (Dental School of Bern), University of Bern, Bern, Switzerland

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Dominic Sasunna Data manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Katrin Bekes Head, Department of Paediatric Dentistry, University Clinic of Dentistry, Medical University of Vienna, Vienna, Austria

Ulrich Schiffner Professor, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

*Shared primary authorship.

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Appendix 1

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/caries-experience-and-care-in-germany-results-of-the-6th-german-oral-health-study-dms-6-online-appendix/.

Prevalence of the periodontal status in Germany: results of the 6th German Oral Health Study (DMS • 6)

Peter Eickholz, Prof Dr med dent/Birte Holtfreter, Priv-Doz Dr rer nat/Kathrin Kuhr, Dr rer medic/
Bettina Dannewitz, Prof Dr med dent/A. Rainer Jordan, Prof Dr med dent, MSc/Thomas Kocher, Prof Dr med dent

Objectives: The 6th German Oral Health Study (DMS • 6) reports on the periodontal status in population-based cohorts of younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds). **Method and materials:** Participants answered questionnaires regarding oral health behavior, and general and oral health status. Probing depth (PD), clinical attachment level (CAL), and bleeding on probing (BOP) were measured on all teeth except third molars. Number of teeth, BOP, mean PD, mean CAL, the stages of the 2018 classification of periodontal diseases, the prevalence of Community Periodontal Index (CPI), and the Centers for Disease Control and Prevention (CDC)/American Academy of Periodontology (AAP) case definition were reported. **Results:** In total, 9.2%/20.6% of younger adults/younger seniors had a low education status, 25.6%/14.1% of younger adults/younger seniors were current smokers, and 2.1%/15.4% of younger adults/younger seniors had type 2 diabetes. Of all younger adults/younger seniors, 24.4%/38.7% stated that they performed interdental cleaning at least daily. The mean number of teeth in dentate younger adults/younger seniors was 26.6/20.4, of which 5.6/8.3 teeth had PD ≥ 4 mm and only 0.6/1.7 teeth had PD ≥ 6 mm. The mean number of teeth with CAL ≥ 5 mm was 1.1/3.6 in younger adults/younger seniors. Mean PD in younger adults/younger seniors was 2.1 mm/2.6 mm; correspondingly, mean CAL was 1.1 mm/2.4 mm. A CPI score of 4 occurred in 16.2%/42.4% of younger adults/younger seniors. In total, 13.6%/26.3% of younger adults/younger seniors were classified as having stage III periodontitis, while 3.9% and 26.4% were classified as having stage IV periodontitis according to the 2018 case classification, respectively. **Conclusion:** The periodontitis prevalence according to the 2018 classification (including all stages) was very high at 95.1%/85.2% in younger adults/younger seniors. In total, 31.6%/8.3% of younger adults/younger seniors were classified as stage I (ie, interdental CAL 1 to 2 mm), which, from a clinical point of view, appears to be a transitional phase between gingivitis and periodontitis, which can probably be managed with preventive rather than therapeutic measures. In younger adults and younger seniors, the prevalence of periodontitis in Germany is high, with severe periodontitis (stages III and IV) in 17.5%/52.7% of younger adults/younger seniors. *(Quintessence Int 2025;56(Suppl):S40–S47; doi: 10.3290/j.qi.b5981979)*

Keywords: classification, dental care, dentists, DMS 6, epidemiology, prevalence, periodontitis

Periodontitis is characterized by attachment and bone loss as well as bleeding on probing (BOP) and periodontal pockets, which extend from the gingival margin to the most coronal extension of the periodontal attachment. The respective coronal landmark for attachment loss is the cementoenamel junction (CEJ). Probing depth (PD) is used to assess the current periodontal status and treatment burden, whereas clinical attachment levels (CAL) indicate the cumulative periodontal disease experience. On a subject level, both measurements can be aggregated and expressed as prevalence (at least one diseased site), extent (number [corresponding to treatment needs] and percentage of affected sites/teeth), and severity (mean PD/CAL).[1] However, health administra-

tors and the general public need a categorical case classification. The current classification, which was introduced by the European Federation of Periodontology (EFP) and the American Academy of Periodontology (AAP) in 2018, characterizes cases of periodontitis according to their severity (complexity, extent) and progression rate using a two-vector system defined by stage and grade.[2]

In 2015, the DMS V study revealed a high prevalence of periodontitis.[3] In turn, the National Association of Statutory Health Insurance Dentists has developed new treatment strategies to address the need for periodontal treatment that is yet to be met. In 2021, a new treatment directive and new treatment codes were added to the code book by the joint committee of care providers and statutory health insurance,[4] based on the EFP/AAP case definition. However, it should be noted that the present data reported do not yet reflect the new directive.

The aim of this publication was to report the periodontal status of younger adults and younger seniors in Germany. As periodontal disease is driven by key risk factors, the health care system must correlate the periodontal status to the exposure profiles, which will help explain existing differences in periodontal status.

Method and materials

The general methodology of the study is presented in separate articles.[5,6] The 6th German Oral Health Study (DMS • 6) has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

In total, 927 younger adults (35- to 44-year-olds) and 797 younger seniors (65- to 74-year-olds) received a clinical examination. Of those, one younger adult and 37 younger seniors were edentulous. Fifteen younger adults and 42 younger seniors met other exclusion criteria for periodontal examination (ie, heart disease record card; hemophilia, immunosuppression after organ transplantation). Therefore, periodontal variables were available for 911 younger adults and 718 younger seniors.

Covariates

Further information was collected in interviews (see Table 1 for parameters). The body mass index was calculated based on height and weight.

Clinical examination

Measurements of PD, CAL, and BOP were recorded with a manual periodontal probe (PCPUNC 15, Zantomed) at six sites per tooth, excluding third molars. PD and CAL measurements were mathematically rounded. PD was measured as the distance between the free gingival margin (FGM) and pocket base. If the CEJ was subgingival, CAL was calculated as PD minus the distance between FGM and CEJ. If recession was present at the examined site, CAL was measured directly as the distance between CEJ and the pocket base. If the CEJ was indistinct (wedge-shaped defects, fillings, crown margins), CAL was not recorded.

Periodontal status reporting and statistical analysis

For dentate participants, the number of teeth (excluding third molars), percentage of sites with BOP, mean PD/CAL, prevalence of PD ≥ 4 / ≥ 6 mm (individuals with at least one site), numbers of teeth and percentages of sites with PD ≥ 4/ ≥ 6 mm, prevalence of CAL ≥ 3 / ≥ 5 mm, and numbers of teeth and percentages of sites with CAL ≥ 3 / ≥ 5 mm were calculated. The 2018 EFP/AAP periodontitis classification[7] was used for assessment, including information about the number of teeth extracted due to periodontitis (participants were asked whether extractions were due to periodontal treatment or high tooth mobility), flaring of maxillary anterior teeth, and the number of occluding pairs of natural teeth. CAL measurements were not available in four younger adults and 61 younger seniors due to crowning (registered as "non-classified"). To obtain population-representative prevalence data, edentate subjects were included in the prevalence calculation. In addition, the Centers for Disease Control and Prevention (CDC)/AAP case definition[8] and the Community Periodontal Index (CPI)[9] were recorded.

Prevalence estimates were weighted using sampling weights to adjust for different probabilities of subject selection and differences in gender, age, and region with respect to the German base population. Numbers (n) are provided without weighting. Detailed information on data handling and statistical methods were described previously.[10]

Results

Baseline characteristics

Approximately 9% of younger adults and 20.6% of younger seniors had a low education status, 25.6% of younger adults and 14.1% of younger seniors were current smokers, and 2.1% of

Table 1 Baseline characteristics of study participants for younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds)

Variable		35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)		912	755
Age, years		40.1 ± 2.9	69.7 ± 2.8
Gender	Male	453 (49.7%)	348 (46.1%)
	Female	458 (50.2%)	407 (53.9%)
	Diverse	1 (0.1%)	0 (0.0%)
Education group	Low	79 (9.2%)	147 (20.6%)
	Medium	401 (46.8%)	346 (48.5%)
	High	376 (43.9%)	221 (31.0%)
Migration history	Yes	199 (23.5%)	96 (13.5%)
	No	649 (76.5%)	615 (86.5%)
Smoking status	Never smoked	497 (54.8%)	363 (48.4%)
	Former smoker	178 (19.6%)	281 (37.5%)
	Current smoker	232 (25.6%)	106 (14.1%)
Body mass index, kg/m²		26.2 ± 5.5	27.3 ± 4.9
	< 25	406 (47.7%)	232 (32.9%)
	25 – < 30	283 (33.3%)	294 (41.6%)
	≥ 30	162 (19.0%)	180 (25.5%)
Diabetes mellitus	No diabetes	874 (96.7%)	630 (84.2%)
	Gestational diabetes	7 (0.8%)	2 (0.3%)
	Type 1 diabetes	4 (0.4%)	1 (0.1%)
	Type 2 diabetes	19 (2.1%)	115 (15.4%)
Tooth brushing (frequency)	> 2 times daily	45 (5.0%)	81 (11.5%)
	2 times daily	698 (77.0%)	509 (72.5%)
	Once daily	138 (15.2%)	85 (12.1%)
	< once daily	26 (2.9%)	27 (3.8%)
Interdental cleaning (frequency)	≥ once daily	221 (24.4%)	272 (38.7%)
	≥ once a week	195 (21.5%)	117 (16.7%)
	< once a week	188 (20.7%)	58 (8.3%)
	Never	303 (33.4%)	255 (36.3%)
Dental floss use (frequency)	≥ once daily	172 (19.0%)	113 (16.1%)
	≥ once a week	176 (19.4%)	80 (11.4%)
	< once a week	172 (19.0%)	57 (8.1%)
	Never	387 (42.7%)	452 (64.4%)
Interdental brushes use (frequency)	≥ once daily	65 (7.2%)	193 (27.5%)
	≥ once a week	53 (5.8%)	68 (9.7%)
	< once a week	68 (7.5%)	34 (4.8%)
	Never	721 (79.5%)	407 (58.0%)
Tooth sticks use (frequency)	≥ once daily	17 (1.9%)	27 (3.8%)
	≥ once a week	20 (2.2%)	22 (3.1%)
	< once a week	10 (1.1%)	5 (0.7%)
	Never	860 (94.8%)	648 (92.3%)
Electric toothbrush use (frequency)	≥ once daily	483 (53.3%)	340 (48.4%)
	≥ once a week	18 (2.0%)	14 (2.0%)
	< once a week	3 (0.3%)	2 (0.3%)
	Never	403 (44.4%)	346 (49.3%)
Dental visits (frequency)	≥ once a year	780 (86.5%)	657 (88.3%)
	< once a year	39 (4.3%)	16 (2.2%)
	Only in case of problems	83 (9.2%)	71 (9.5%)

Table 1 Baseline characteristics of study participants for younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds)

Variable		35- to 44-year-olds	65- to 74-year-olds
Dental service utilization	Complaint-oriented	120 (13.2%)	92 (12.3%)
	Control-oriented	787 (86.8%)	657 (87.7%)
Professional tooth cleaning (utilization)	Yes	711 (78.9%)	587 (78.8%)
	No	188 (20.9%)	155 (20.8%)
	Don't know	2 (0.2%)	3 (0.4%)
Professional tooth cleaning (frequency)	Never	188 (21.0%)	155 (21.8%)
	Usually no professional tooth cleaning	105 (11.7%)	90 (12.7%)
	< once every 2 years	60 (6.7%)	43 (6.0%)
	≥ once every 2 years	54 (6.0%)	30 (4.2%)
	≥ once a year	314 (35.0%)	207 (29.1%)
	≥ once every 6 months	175 (19.5%)	186 (26.2%)
PD measurement during professional tooth cleaning	Yes	227 (36.1%)	215 (44.1%)
	No	303 (48.2%)	208 (42.6%)
	Don't know	99 (15.7%)	65 (13.3%)
Lifetime periodontal treatment (utilization)	Yes	112 (12.4%)	241 (32.3%)
	No	766 (84.9%)	478 (64.0%)
	Don't know	24 (2.7%)	28 (3.7%)

Data are presented as number (percentage) or mean ± standard deviation based on unweighted data for edentate and dentate participants with complete periodontal findings. PD, probing depth.

younger adults and 15.4% of younger seniors had type 2 diabetes (Table 1). At least daily interdental cleaning was stated by 24.4% of younger adults and 38.7% of younger seniors, respectively. Professional tooth cleaning at least every 6 months was reported by 19.5% of younger adults and 26.2% of younger seniors, while periodontal treatment during their lifetime was reported by 12.4% of younger adults and 32.3% of younger seniors.

Periodontitis prevalence, extent, and severity

The mean number of teeth in dentate patients was 26.6 in younger adults and 20.4 in younger seniors, of which 5.6/8.3 teeth had PD ≥ 4 mm and 0.6/1.7 teeth had PD ≥ 6 mm (Table 2). The mean number of teeth with CAL ≥ 5 mm was 1.1/3.6 in younger adults/younger seniors. The mean PD was 2.1 mm/ 2.6 mm; the mean CAL was 1.1 mm/2.4 mm.

According to the EFP/AAP classification (Table 3), 4.3% of younger adults were periodontally healthy or had gingivitis. Fourteen per cent of younger adults (grade B: 36.3%; grade C: 63.7%) and 26.3% of younger seniors (grade B: 80.5%; grade C: 18.1%) were classified as having stage III periodontitis, respectively. Stage IV periodontitis was present in 3.9% of younger adults (grade B: 21.0%; grade C: 79.0%) and in 26.4% of younger seniors (grade B: 71.2%; grade C: 28.8%), respectively.

The prevalence, severity, and extent of periodontitis were consistently higher in men than in women (Table 2).

A CPI score of 4 occurred in 16.2%/42.4% of younger adults/younger seniors (Table 4). Breaking it down by tooth, molars and premolars were more often extracted than incisors. Percentages of present teeth with PD ≥ 4 mm were highest for molars, followed by premolars and incisors (Appendix 1). Patterns were similar in the maxilla and mandible.

Distribution pattern according to periodontal risk factors

Both in younger adults and younger seniors, the prevalence of stage IV periodontitis was higher in people with a low education status, smokers, and diabetics but lower in people with favorable oral hygiene behavior (Appendix 2).

Discussion

According to the 2018 EFP/AAP classification, the prevalence of periodontitis was very high at 95.1% in younger adults and 85.2% in younger seniors, and periodontal health and gingivitis were rare. In total, 17.5% of younger adults and 52.7% of younger seniors were classified as stage III or IV. This is a conservative estimate because the proportion of non-classifiable

Table 2 Prevalence, severity, and extent of periodontitis in dentate younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds)

Variable		35- to 44-year-olds			65- to 74-year-olds		
		Total	Male	Female	Total	Male	Female
No. of participants (n)		911	452	458	718	327	391
BOP (% sites)		14.2 (13.1; 15.3)	13.8 (12.2; 15.3)	14.7 (13.1; 16.3)	20.4 (18.9; 22.0)	20.8 (18.7; 22.9)	20.0 (17.8; 22.3)
PD	Mean PD, mm	2.1 (2.1; 2.2)	2.2 (2.2; 2.3)	2.1 (2.0; 2.1)	2.6 (2.6; 2.7)	2.8 (2.7; 2.9)	2.5 (2.4; 2.5)
	PD ≥ 4 mm (prevalence)	73.2% (70.3; 76.0)	76.0% (71.8; 79.7)	70.3% (66.0; 74.2)	91.3% (88.9; 93.1)	93.4% (90.4; 95.7)	89.4% (86.1; 92.3)
	PD ≥ 6 mm (prevalence)	16.2% (13.9; 18.7)	21.0% (17.3; 24.9)	11.8% (9.1; 14.9)	44.8% (41.1; 48.4)	55.2% (49.9; 60.5)	35.7% (30.8; 40.4)
	Number of teeth with PD ≥ 4 mm	5.6 (5.2; 6.1)	6.7 (6.0; 7.4)	4.5 (4.0; 5.1)	8.3 (7.8; 8.8)	9.8 (9.1; 10.5)	7.0 (6.4; 7.6)
	Number of teeth with PD ≥ 4 mm in periodontally diseased persons*	7.9 (7.3; 8.4)	9.0 (8.1; 9.8)	6.7 (6.0; 7.5)	9.4 (8.9; 9.9)	10.7 (9.9; 11.4)	8.2 (7.6; 8.9)
	Number of teeth with PD ≥ 6 mm	0.6 (0.5; 0.8)	0.9 (0.7; 1.1)	0.4 (0.2; 0.5)	1.7 (1.5; 1.9)	2.4 (2.0; 2.8)	1.0 (0.8; 1.3)
	Percentage of sites with PD ≥ 4 mm (%)	7.9 (7.0; 8.8)	9.6 (8.3; 11.0)	6.3 (5.2; 7.5)	19.0 (17.4; 20.5)	23.3 (20.9; 25.8)	15.2 (13.3; 17.0)
	Percentage of sites with PD ≥ 6 mm (%)	0.7 (0.5; 0.9)	1.0 (0.7; 1.4)	0.4 (0.2; 0.5)	3.1 (2.6; 3.7)	4.3 (3.4; 5.2)	2.0 (1.4; 2.7)
CAL	Mean CAL, mm	1.1 (1.1; 1.2)	1.2 (1.1; 1.3)	1.0 (0.9; 1.1)	2.4 (2.3; 2.5)	2.7 (2.5; 2.9)	2.1 (2.0; 2.3)
	CAL ≥ 3 mm (prevalence)	80.2% (77.5; 82.7)	83.6% (79.9; 86.8)	76.9% (72.9; 80.6)	95.7% (94.0; 97.1)	96.2% (93.6; 97.9)	95.2% (92.4; 97.0)
	CAL ≥ 5 mm (prevalence)	25.3% (22.5; 28.2)	30.5% (26.4; 35.0)	20.4% (16.8; 24.1)	66.6% (63.0; 70.2)	76.8% (71.9; 81.3)	57.3% (52.0; 62.4)
	Number of teeth with CAL ≥ 3 mm	6.9 (6.5; 7.4)	7.9 (7.2; 8.6)	5.9 (5.3; 6.5)	9.7 (9.2; 10.2)	11.1 (10.3; 11.9)	8.4 (7.8; 9.1)
	Number of teeth with CAL ≥ 5 mm	1.1 (0.9; 1.3)	1.6 (1.2; 1.9)	0.7 (0.5; 0.8)	3.6 (3.2; 3.9)	4.8 (4.2; 5.4)	2.4 (2.0; 2.8)
	Percentage of sites with CAL ≥ 3 mm (%)	11.5 (10.3; 12.8)	13.5 (11.6; 15.5)	9.4 (7.8; 10.9)	38.8 (36.3; 41.2)	45.7 (42.0; 49.4)	32.5 (29.3; 35.7)
	Percentage of sites with CAL ≥ 5 mm (%)	1.5 (1.1; 1.8)	2.1 (1.5; 2.8)	0.8 (0.5; 1.2)	12.7 (11.1; 14.4)	17.5 (14.8; 20.3)	8.4 (6.6; 10.2)
Number of teeth		26.6 (26.5; 26.8)	26.6 (26.4; 26.8)	26.6 (26.4; 26.9)	20.4 (19.9; 20.9)	20.8 (20.0; 21.5)	20.1 (19.4; 20.8)

Data are presented as unweighted numbers (n) and weighted percentages or weighted means (with 95% confidence intervals) for dentate participants with complete periodontal findings. One gender-diverse individual is included in the total column, but not in the gender categories.
*Defined as periodontitis cases according to the 2018 gingivitis and periodontitis classification schemes (Stage I–V) having ≥ 1 tooth with PD ≥ 4 mm.
BOP, bleeding on probing; CAL, clinical attachment level; PD, probing depth.

subjects is included as a valid category in the prevalence calculation, and it is not to be expected that these individuals will consistently have no periodontal disease. In comparison, lower prevalences of stage III/IV periodontitis were reported for mainland China (2015 to 2016; 10.6% and 43.5% in 35- to 44- and 65- to 74-year-olds, respectively).[11] Among studies reporting prevalences for the total population only, prevalences of stage III/IV were 35.1% in ≥ 30-year-old Americans (2009 to 2014),[12] and 17.6% in ≥ 19-year-olds in Norway (HUNT4; 2017 to 2019).[13] However, it should be noted that severity and complexity factors considered for staging differed among the studies, which may partly explain differences in prevalence.

In view of the high prevalence of periodontitis in the DMS • 6, the question arises as to whether it makes sense to classify a condition that occurs in more than 80% of the population as a disease. In DMS • 6, 31.6% of younger adults and 8.3% of younger seniors were classified as stage I (ie, interdental CAL 1 to 2 mm). Depending on the degree of periodontal inflammation, the probe will penetrate beyond the apical termination of the junctional epithelium into the inflamed adjacent connective tissue, and the true periodontal pocket will be overestimated.[14] Furthermore, the measurement error of clinical measurements of PD and CAL ranges between 0.5 and 1 mm.[15] Reliability data from the DMS • 6 showed that only 32.6% and 35% of repeated PD and CAL measurements, respectively, deviated by ± 1 mm, indicating even higher variability. In addition, the CEJ is located apical to the gingival margin in subjects with incipient periodontitis, making CEJ detection difficult and CAL assessment even more challenging. Due to this overestimation in inflamed sites and a CAL measurement error of approximately ± 1 mm, it is very likely that a high proportion of stage I in DMS • 6 was not periodontitis but gingivitis. In addition, only 47.9% of younger adults and 63.1% of younger seniors had at least one tooth with a PD ≥ 4 mm, although they were classified as having stage I periodontitis. Thus, 52% of younger adults and 37% of younger seniors with stage I periodontitis would not qualify for comprehensive periodontal treatment according to the German directive for the systematic treatment of

Table 3 Categorization according to the 2018 EFP/AAP periodontitis classification in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds)

Age group	Variable		Prevalence cases	% Cases with ≥ 1 tooth with PD ≥ 4 mm	% Cases with grade A	% Cases with grade B	% Cases with grade C
35- to 44-year-olds	No. of participants (n)		912	NA	NA	NA	NA
	Periodontal health		3.8% (2.7; 5.2)	NA	NA	NA	NA
	Gingivitis		0.5% (0.2; 1.5)	NA	NA	NA	NA
	Periodontitis cases	All stages	95.1% (85.6; 100.0)	NA	NA	NA	NA
		Stage I	31.6% (28.6; 34.7)	47.9 (42.4; 53.9)	17.3 (13.3; 22.0)	77.9 (72.8; 82.3)	4.8 (2.8; 7.8)
		Stage II	46.0% (42.8; 49.2)	80.9 (76.8; 84.3)	0.0 (NA)	84.2 (80.4; 87.3)	15.8 (12.7; 19.6)
		Stage III	13.6% (11.5; 15.9)	98.8 (96.3; 99.9)	0.0 (NA)	36.3 (28.2; 45.0)	63.7 (55.0; 71.8)
		Stage IV	3.9% (2.7; 5.2)	97.9 (93.1; 100.0)	0.0 (NA)	21.0 (9.4; 35.3)	79.0 (64.7; 90.6)
	Edentulous		0.1% (0.0; 0.5)	NA	NA	NA	NA
	Non-classified*		0.5% (0.1; 1.0)	NA	NA	NA	NA
65- to 74-year-olds	No. of participants (n)		755	NA	NA	NA	NA
	Periodontal health		0.0% (NA)	NA	NA	NA	NA
	Gingivitis		0.0% (NA)	NA	NA	NA	NA
	Periodontitis cases	All stages	85.2% (74.4; 97.0)	NA	NA	NA	NA
		Stage I	8.3% (6.5; 10.5)	63.1 (51.2; 74.6)	87.2 (77.5; 93.8)	5.8 (2.2; 14.4)	6.9 (2.2; 14.4)
		Stage II	24.2% (21.3; 27.4)	91.2 (86.5; 94.7)	0.0 (NA)	93.8 (89.2; 96.4)	6.2 (3.2; 10.2)
		Stage III	26.3% (23.2; 29.4)	96.7 (93.9; 98.7)	1.5 (0.4; 4.0)	80.5 (74.3; 85.4)	18.1 (13.3; 24.0)
		Stage IV	26.4% (23.4; 29.7)	97.4 (93.9; 98.7)	0.0 (NA)	71.2 (64.4; 77.0)	28.8 (23.0; 35.6)
	Edentulous		5.3% (3.9; 7.1)	NA	NA	NA	NA
	Non-classified*		9.5% (7.5; 11.6)	NA	NA	NA	NA

Data are presented as unweighted numbers (n) and weighted percentages (with 95% confidence intervals) for edentate and dentate participants with complete periodontal findings.
EFP/AAP, European Federation of Periodontology/American Academy of Periodontology; NA, not available.
*Periodontitis case definition not applicable.

periodontal disease.[4] Stage I periodontitis appears to be a transitional phase between gingivitis and incipient periodontitis that is likely to be managed with preventive measures (ie, improved individual oral hygiene and professional mechanical plaque removal) rather than subgingival instrumentation. If clinically diagnosed stage I periodontitis progresses to stage II (interdental CAL 3 to 4 mm) despite preventive measures, it can be detected by monitoring the patient, and comprehensive treatment can still be initiated at an early stage. With 86.8% of younger adults and 87.7% of younger seniors showing a control-oriented dental service utilization (Table 1), the likelihood of preventing progression to stages III and IV is high.

In contrast to the present epidemiologic study, most dental practitioners in German clinical practice determine the periodontal stage based on radiographs and not based on CAL. On radiographs, only a significant amount of bone destruction can be detected.[16] The difference between CAL and radiographic crest height can range from 0 to 1.6 mm. Physiologic bone levels range from 1.0 to 3.0 mm apical to the CEJ.[17] Therefore, an overestimation of incipient stage I periodontitis in general dental practice is unlikely.

Over the last decade, the change in the threshold between health and disease has triggered heated debates in many medical fields. On the one hand, the threshold for hypertension was lowered from 140 to 120 mmHg for systolic and from 90 to 80 mmHg for diastolic blood pressure. However, it has been questioned whether the mortality of patients with such low blood pressure is really reduced by the required lifelong medication.[18] On the other hand, the strict threshold of 6.5% HbA1c for diagnosis of type 2 diabetes was raised to 8.5% in older diabetes patients, as no life-prolonging effect was found.[19] As CAL was the decisive factor in the EFP/AAP classification (Appendix 3), a CAL threshold of ≥ 5 mm in the elderly may be too strict for classification of stage III and IV periodontitis, as teeth with CAL ≥ 5 mm are not extracted exclusively due to periodontitis.[20] These examples clearly illustrate that medical thresholds are subject to ongoing evaluation and adaptation.

Table 4 Community Periodontal Index and CDC/AAP case definition in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds)

Variable		35- to 44-year-olds			65- to 74-year-olds		
		Total	Male	Female	Total	Male	Female
Community Periodontal Index	Score 0, 1, or 2	26.8% (24.0; 29.7)	24.0% (20.3; 28.2)	29.7% (25.8; 34.0)	8.2% (6.4; 10.3)	6.1% (4.0; 9.0)	10.2% (7.4; 13.4)
	Score 3	56.9% (53.6; 60.0)	54.9% (50.4; 59.6)	58.5% (53.9; 62.9)	44.0% (40.5; 47.5)	35.6% (30.8; 40.7)	51.7% (46.7; 56.5)
	Score 4	16.2% (13.9; 18.7)	21.0% (17.3; 24.9)	11.8% (9.1; 14.9)	42.4% (38.9; 45.9)	51.4% (46.4; 56.7)	34.3% (29.6; 39.0)
	Edentulous	0.1% (0.0; 0.5)	0.1% (0.0; 1.0)	0.0% (NA)	5.3% (3.9; 7.1)	6.9% (4.7; 9.9)	3.9% (2.2; 6.0)
CDC/AAP case definition	No or mild periodontitis	66.1% (62.9; 69.0)	62.0% (57.4; 66.4)	70.3% (66.0; 74.2)	21.7% (18.9; 24.8)	13.4% (10.1; 17.2)	29.2% (25.0; 34.0)
	Moderate periodontitis	28.1% (25.2; 31.1)	29.6% (25.6; 34.0)	26.3% (22.5; 30.5)	42.3% (38.8; 45.8)	42.7% (37.9; 48.1)	41.9% (37.2; 46.9)
	Severe periodontitis	5.3% (3.9; 6.8)	8.3% (6.0; 11.2)	2.5% (1.4; 4.3)	22.3% (19.4; 25.3)	29.9% (25.2; 34.7)	15.5% (12.1; 19.3)
	Edentulous	0.1% (0.0; 0.5)	0.1% (0.0; 1.0)	0.0% (NA)	5.3% (3.9; 7.1)	6.9% (4.7; 9.9)	3.9% (2.2; 6.0)
	Non-classified*	0.5% (0.1; 1.0)	0.0% (NA)	0.9% (0.3; 2.0)	8.4% (6.5; 10.5)	7.2% (4.9; 10.3)	9.5% (7.0; 12.8)

Data are presented as weighted percentages (with 95% confidence intervals) for edentate and dentate participants with complete periodontal findings. One gender-diverse individual is included in the total column, but not in the gender categories.
*Dentate participants with < 2 teeth with valid information on interdental clinical attachment level.
AAP, American Academy of Periodontology; CDC, Centers for Disease Control; NA, not available.

Conclusion

In Germany, the prevalence of periodontitis was high in both younger adults and younger seniors, with severe periodontitis (stage III and IV) diagnosed in 17.5% of younger adults and 52.7% of younger seniors. With a substantial proportion of stage I cases likely to be due to overestimation and measurement error, the classification of stage I periodontitis as a disease may be questioned.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper contributed sufficiently to fulfil the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. PE is a member of the DMS • 6 scientific advisory board, responsible for developing the clinical examinations, and the author of the manuscript. BH is a scientific advisor of the DMS • 6 and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. BD is a co-author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. TK is a member of the DMS • 6 scientific advisory board, responsible for developing the clinical examinations, and a co-author of the manuscript.

References

1. Holtfreter B, Albandar JM, Dietrich T, et al. Standards for reporting chronic periodontitis prevalence and severity in epidemiologic studies: Proposed standards from the Joint EU/USA Periodontal Epidemiology Working Group. J Clin Periodontol 2015;42:407–412.
2. Tonetti MS, Greenwell H, Kornman KS. Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. J Clin Periodontol 2018; 45:P149–P161.
3. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.
4. Gemeinsamer Bundesausschuss. Richtlinie zur systematischen Behandlung von Parodontitis und anderer Parodontalerkrankungen (PAR-Richtlinie). Berlin: G-BA, 2020.

5. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

6. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

7. Holtfreter B, Kuhr K, Borof K, et al. ACES: A new framework for the application of the 2018 periodontal status classification scheme to epidemiological survey data. J Clin Periodontol 2024;51:512–521.

8. Page RC, Eke PI. Case definitions for use in population-based surveillance of periodontitis. J Periodontol 2007;78:1387–1399.

9. Ainamo J, Barmes D, Beagrie G, Cutress T, Martin J, Sardo-Infirri J. Development of the World Health Organization (WHO) community periodontal index of treatment needs (CPITN). Int Dent J 1982;32:281–291.

10. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

11. Jiao J, Jing W, Si Y, et al. The prevalence and severity of periodontal disease in Mainland China: Data from the Fourth National Oral Health Survey (2015–2016). J Clin Periodontol 2021;48:168–179.

12. Du M, Mo Y, an Li, Ge S, Peres MA. Assessing the surveillance use of 2018 EFP/AAP classification of periodontitis: A validation study and clustering analysis. J Periodontol 2023;94:1254–1265.

13. Stødle IH, Verket A, Høvik H, Sen A, Koldsland OC. Prevalence of periodontitis based on the 2017 classification in a Norwegian population: The HUNT study. J Clin Periodontol 2021;48:1189–1199.

14. Listgarten MA. Periodontal probing: what does it mean? J Clin Periodontol 1980;7:165–176.

15. Goodson JM. Clinical measurements of periodontitis. J Clin Periodontol 1986;13: 446–460.

16. Zaki HA, Hoffmann KR, Hausmann E, Scannapieco FA. Is radiologic assessment of alveolar crest height useful to monitor periodontal disease activity? Dent Clin North Am 2015;59:859–872.

17. Chapple ILC, Mealey BL, van Dyke TE, et al. Periodontal health and gingival diseases and conditions on an intact and a reduced periodontium: Consensus report of workgroup 1 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Clin Periodontol 2018;45(Suppl 1):S68–S77.

18. Atasoy S, Johar H, Peters A, Ladwig K-H. Association of hypertension cut-off values with 10-year cardiovascular mortality and clinical consequences: a real-world perspective from the prospective MONICA/KORA study. Eur Heart J 2019;40:732–738.

19. Bundesärztekammer, Kassenärztliche Bundesvereinigung, Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften. Nationale Versorgungsleitlinie Typ-2-Diabetes – Leitlinienreport. AWMF online, 2023.

20. Rug J, Holtfreter B, Völzke H, Kocher T. Have extraction patterns in German younger adults with severe periodontitis changed between 2000 and 2010? Results from two cohort studies. J Clin Periodontol 2023;50: 463–475.

Peter Eickholz

Peter Eickholz Chair, Department of Periodontology, Center of Dentistry and Oral Medicine (Carolinum), Johann Wolfgang Goethe University, Frankfurt/Main, Germany

Birte Holtfreter Senior Researcher, Department of Restorative Dentistry, Periodontology and Endodontology, University Medicine Greifswald, Greifswald, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Bettina Dannewitz Dentist, Dannewitz & Glass Dental Practice, Weilburg, Germany; and Associate Professor, Department of Periodontology, Center of Dentistry and Oral Medicine (Carolinum), Johann Wolfgang Goethe University, Frankfurt/Main, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Thomas Kocher Senior Professor, Department of Restorative Dentistry, Periodontology and Endodontology, University Medicine Greifswald, Greifswald, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Appendix 1 to 3

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/prevalence-of-the-periodontal-status-in-germany-results-of-the-6th-german-oral-health-study-dms-6-online-appendix/.

Trends in periodontal status: results from the German Oral Health Studies from 2005 to 2023

Thomas Kocher, Prof Dr med dent/Peter Eickholz, Prof Dr med dent/Kathrin Kuhr, Dr rer medic/
A. Rainer Jordan, Prof Dr med dent, MSc/Dominic Sasunna/Vinay Pitchika, PhD/Birte Holtfreter, Priv-Doz Dr rer nat

Objectives: The objective of this study was twofold: firstly, to provide an overview of trends in periodontal status among younger adults aged 35 to 44 years and younger seniors aged 65 to 74 years between 2005 and 2023, based on data from the German Oral Health Studies (DMS); secondly, to quantify the extent to which observed differences in tooth count variables between consecutive studies can be attributed to differences in characteristics. **Method and materials:** The data from DMS IV (2005), DMS V (2014), and DMS • 6 (2023) were analyzed. The participants completed questionnaires concerning their oral health behaviors, and general and oral health. For this analysis, probing depths (PD) were calculated from three sites on 12 index teeth as a common denominator. The number of teeth, severity, and extent of PD and the Community Periodontal Index (CPI) were reported. Multivariate decomposition was employed to analyze differences by time. **Results:** The proportion of edentate younger seniors notably declined, from 23.2% to 5.4%, between 2005 and 2023. Similarly, the mean number of teeth for dentate younger seniors was 2.4 teeth higher in DMS • 6. While the mean PD remained 2.4 mm for younger adults and 2.8 mm for younger seniors, inconsistent patterns were observed for extent variables. In most cases, a decline of the extent variables was observed between DMS IV and DMS V, with a rebound at DMS • 6 for severe cases in younger seniors (with PD ≥ 6 mm). The proportion of younger adults and seniors with CPI scores of 0 to 2 increased considerably between DMS IV and DMS V, but rebounded at DMS • 6. Overall, the prevalence of these cases increased by approximately 10% points and 5% points, respectively. The majority of the observed reduction in the number of missing teeth (in younger adults) or the prevalence of having less than 20 teeth (in younger seniors) between DMS IV and DMS V and between DMS V and DMS • 6 were explained by an increase in the proportion of highly educated individuals, an increase in the proportion of those who have never smoked (only younger adults), an increase in the proportion of individuals using electric toothbrushes or interdental cleaning devices, and a reduction in the proportion of individuals with lifetime periodontal treatment. **Conclusion:** Over the last two decades, there has been a significant improvement in periodontal health in Germany, with the most notable enhancements occurring between DMS IV and DMS V. The prevalence of periodontal disease has decreased significantly in recent decades, largely due to the implementation of preventive measures. This underscores the importance of integrating preventive measures into dental practice as a public health strategy. *(Quintessence Int 2025;56(Suppl):S48–S58; doi: 10.3290/j.qi.b5981996)*

Keywords: dental care, dentists, DMS 6, multivariate decomposition, number of missing teeth, periodontitis, trend analysis

The German Oral Health Studies (DMS), which have been repeatedly conducted since 1997 and are representative of the population in Germany, have revealed a significant improvement in oral health. Between 1997 (DMS III) and 2014 (DMS V), the prevalence of edentulism in adults and seniors decreased from 1.1% and 24.8% to 0.8% and 12.4%, respectively. The mean number of teeth increased from 23.8 and 10.4 to 25.9 and 16.9, respectively.[1] In addition, the prevalence of periodontitis decreased, as indicated by a reduction in Community Periodontal Index (CPI) score 4 from 9.3% and 10.5% to 3.5% and 9.8%, respectively. This raised the question of whether this improvement would continue in the current 6th German Oral Health Study (DMS • 6) and whether the retention of more teeth would increase the need for periodontal treatment.

Representative, population-wide health surveys can be used to assess the prevalence of diseases and their determinants, and thus to analyze past developments and possibly extrapolate future trends. Health surveys are a prerequisite for sustainable and effective changes or improvements in the structures of a health care system. In addition to the prevalence of diseases, the prevalence of upstream (prevention strategies for the whole community) and downstream (individual treatment) determinants may change over time. An example of an upstream determinant is the restriction on smoking. As a result of legislative measures, fewer and fewer men have taken up smoking in Germany over recent decades, which is reflected in the lower number of lung cancer cases.[2] As an example of a downstream determinant, the increased use of interdental cleaning aids and electric toothbrushes has contributed to an increase in the number of teeth.[3] Only repeated cross-sectional studies can detect changes in the prevalence of a disease and its determinants. If prevalence data are available for both the disease and the risk factors, it is possible to determine whether changes in the prevalence of a risk factor have contributed to changes in the prevalence of the disease.

The aim of the present study was to evaluate trends in periodontal status, the number of teeth, and edentulism using data from three repeated national DMS studies (DMS IV, DMS V, DMS • 6). It was also examined whether changes in the number of missing teeth could be explained by changes in the main determinants of oral health.

Method and materials

Repeated cross-sectional data from 2005 (DMS IV), 2014 (DMS V), and 2023 (DMS • 6) were analyzed separately for younger adults and younger seniors*. The design, sampling, and non-response analyses of DMS IV, V, and 6 have been described in detail elsewhere.[4-7] This analysis included data from 923/1,013, 966/1,019, and 912/740 younger adults/younger seniors from DMS IV, DMS V, and DMS • 6, respectively.

In DMS IV and V, probing depth (PD) was measured at midbuccal, mesiobuccal, and distolingual sites on 12 index teeth (teeth 17, 16, 11, 24, 26, 27, 47, 46, 44, 31, 36, 37, according to FDI notation) using a WHO periodontal probe (PCP 11.5 WHO probe, M+W Dental). In DMS • 6, PD was recorded at six sites on all present teeth except third molars using a 1-mm marked periodontal probe (PCPUNC 15, Zantomed). In order to ensure comparability between the three studies, only measurements from the 12 index teeth with three sites each were used for the current analysis. PD measurements were used to compare periodontal status between waves.

At each DMS wave, an interview was conducted and a selection of demographic, medical, and dental determinants were recorded. When necessary, questions were harmonized across waves to ensure consistency: age, gender, school education (< 10/10/> 10 years), smoking status (never/former/current smoker), body mass index (BMI), diabetes mellitus (yes/no), tooth brushing frequency (at least twice daily, less than twice daily), use of interdental aids (dental floss, toothpicks, interdental brushes, or multiuser [yes/no]), use of an electric toothbrush (yes/no), frequency of dental visits (more than once a year, once a year, rarely), dental service utilization (complaint-oriented, control-oriented), lifetime periodontal treatment (yes/no).

Statistical analysis

Multivariate decomposition[8] was employed to estimate the extent to which differences in the distribution of the dependent variable between two examinations (DMS IV and DMS V; DMS V and DMS • 6) are attributable to differences in distributions of independent variables (ie, differences in characteristics). In particular, the differences in the distribution of the dependent variables between consecutive DMS studies were decomposed into those attributable to differences in the distributions of independent variables (also referred to as "differences in characteristics" or the "explained component" or "characteristics effects") and those resulting from differences in the associations of independent variables and tooth count variables within studies (also referred to as "differences in coefficients" or "unexplained component" or "coefficient effects"). Decompositions were calculated for Poisson (younger adults: "number of missing teeth" as dependent variable) and logistic regression models (younger seniors: "having less than 20 teeth" as dependent variable). The models for differences in characteristics were reported, including beta coefficients and 95% confidence intervals (CIs). The differences in characteristics models assist in determining the extent to which observed changes in the dependent variable can be attributed to changes in the independent variables.

*In DMS IV and V, participants aged 35 to 44 years were referred to as "adults" and those aged 65 to 75 years as "seniors." Here, we are using the terminology of DMS • 6: "younger adults" (35- to 44-year-olds) and "younger seniors" (65- to 74-year-olds).

Table 1 Baseline characteristics of study participants for younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) in DMS IV, DMS V, and DMS • 6

Variable		DMS IV		DMS V		DMS • 6	
		35- to 44-year-olds	65- to 74-year-olds	35- to 44-year-olds	65- to 74-year-olds	35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)		923	1,013	966	1,019	912	740
Age, years		39.0 ± 2.9	68.8 ± 2.7	39.8 ± 2.9	69.4 ± 3.0	40.1 ± 2.9	69.7 ± 2.8
	Missing	0	0	5	1	1	1
Gender	Male	406 (44.0%)	473 (46.7%)	453 (46.9%)	476 (46.7%)	453 (49.7%)	343 (46.4%)
	Female	517 (56.0%)	540 (53.3%)	513 (53.1%)	543 (53.3%)	458 (50.2%)	397 (53.6%)
	Diverse	NA	NA	NA	NA	1 (0.1%)	0 (0.0%)
	Missing	0	0	0	0	0	0
School education	< 10 years	198 (21.7%)	647 (65.6%)	160 (16.6%)	465 (47.3%)	83 (9.7%)	170 (24.3%)
	10 years	421 (46.1%)	171 (17.3%)	391 (40.6%)	261 (26.5%)	265 (31.1%)	261 (37.3%)
	> 10 years	294 (32.2%)	168 (17.0%)	413 (42.8%)	258 (26.2%)	504 (59.2%)	269 (38.4%)
	Missing	10	27	2	35	60	40
Smoking status	Never smoked	410 (44.8%)	614 (61.8%)	451 (46.8%)	537 (53.0%)	497 (54.8%)	360 (48.9%)
	Former smoker	182 (19.9%)	295 (29.7%)	238 (24.7%)	356 (35.1%)	178 (19.6%)	279 (37.9%)
	Current smoker	323 (35.3%)	84 (8.5%)	274 (28.5%)	121 (11.9%)	232 (25.6%)	97 (13.2%)
	Missing	8	20	3	5	5	4
Body mass index, kg/m^2		25.6 ± 5.3	27.4 ± 4.4	26.0 ± 5.0	27.2 ± 4.5	26.2 ± 5.5	27.3 ± 4.9
	Missing	6	24	10	21	61	46
Diabetes mellitus	No	NA	817 (83.4%)	947 (98.0%)	856 (84.0%)	881 (97.5%)	621 (84.6%)
	Yes	NA	163 (16.6%)	19 (2.0%)	163 (16.0%)	23 (2.5%)	113 (15.4%)
	Missing	NA	33	0	0	8	6
Tooth brushing (frequency)	≥ 2 times daily	780 (85.1%)	797 (80.3%)	800 (83.1%)	855 (84.2%)	743 (81.9%)	579 (83.9%)
	< 2 times daily	137 (14.9%)	196 (19.3%)	163 (16.9%)	160 (15.8%)	164 (18.1%)	111 (16.1%)
	Missing	6	20	3	4	5	50
Interdental cleaning aids (utilization)	No	416 (45.1%)	683 (67.4%)	367 (38.0%)	503 (49.4%)	303 (33.4%)	244 (35.4%)
	Dental floss	291 (31.5%)	85 (8.4%)	338 (35.0%)	120 (11.8%)	381 (42.0%)	110 (15.9%)
	Toothpick	75 (8.1%)	84 (8.3%)	48 (5.0%)	64 (6.3%)	17 (1.9%)	29 (4.2%)
	Interdental brushes	33 (3.6%)	90 (8.9%)	65 (6.7%)	187 (18.4%)	64 (7.1%)	160 (23.2%)
	Multiuser	108 (11.7%)	71 (7.0%)	148 (15.3%)	145 (14.2%)	142 (15.7%)	147 (21.3%)
	Missing	0	0	0	0	5	50
Electric toothbrush (utilization)	No	577 (62.5%)	839 (82.8%)	505 (52.3%)	672 (65.9%)	403 (44.4%)	335 (48.6%)
	Yes	346 (37.5%)	174 (17.2%)	461 (47.7%)	347 (34.1%)	504 (55.6%)	355 (51.4%)
	Missing	0	0	0	0	5	50
Dental visits (frequency)	> once a year	583 (63.7%)	523 (53.0%)	560 (58.4%)	641 (64.3%)	419 (46.5%)	400 (54.8%)
	Once a year	242 (26.4%)	269 (27.3%)	273 (28.5%)	247 (24.8%)	361 (40.0%)	248 (34.0%)
	Rarely	90 (9.8%)	194 (19.7%)	126 (13.1%)	109 (10.9%)	122 (13.5%)	82 (11.2%)
	Missing	8	27	7	22	10	10
Dental service utilization	Complaint-oriented	69 (7.6%)	140 (14.7%)	94 (9.8%)	88 (8.6%)	120 (13.2%)	87 (11.8%)
	Control-oriented	842 (92.4%)	815 (85.3%)	867 (90.2%)	930 (91.4%)	787 (86.8%)	648 (88.2%)
	Missing	12	58	5	1	5	5
Lifetime periodontal treatment (utilization)	Yes	223 (24.3%)	383 (38.9%)	192 (20.1%)	418 (41.7%)	112 (12.4%)	234 (31.9%)
	No	693 (75.7%)	602 (61.1%)	764 (79.9%)	585 (58.3%)	790 (87.6%)	499 (68.1%)
	Missing	7	28	10	16	10	7

Data are presented as numbers (percentages) or mean ± standard deviation based on unweighted data for edentate and dentate participants with complete periodontal findings (partial recording protocol: 12 index teeth with 3 sites).
NA, not available.

Table 2 Trends of prevalence, severity, and extent of periodontitis and the Community Periodontal Index (CPI) in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) from DMS IV to DMS • 6

Variable		35- to 44-year-olds			65- to 74-year-olds		
		DMS IV	DMS V	DMS • 6	DMS IV	DMS V	DMS • 6
No. of participants (n)	Including edentates	923	966	912	1,013	1,019	740
	Dentates only	914	962	911	773	902	703
The following data refer to a maximum of 28 teeth							
Edentulism (prevalence)		1.0% (0.5; 1.8)	0.8% (0.3; 1.4)	0.1% (0.0; 0.5)	23.2% (20.7; 25.8)	12.7% (10.7; 14.8)	5.4% (3.9; 7.2)
No. of teeth, including edentates		25.3 (25.0; 25.5)	25.9 (25.7; 26.2)	26.6 (26.5; 26.8)	14.1 (13.5; 14.7)	17.2 (16.7; 17.7)	19.6 (19.0; 20.2)
< 20 teeth, including edentates (prevalence)		5.4% (4.0; 6.9)	3.2% (2.2; 4.5)	2.1% (1.3; 3.2)	59.3% (56.2; 62.3)	45.4% (42.4; 48.5)	36.8% (33.4; 40.4)
< 20 teeth, dentates only (prevalence)		4.4% (3.3; 6.0)	2.5% (1.7; 3.6)	2.1% (1.3; 3.2)	47.0% (43.6; 50.6)	37.5% (34.4; 40.7)	33.2% (29.7; 36.6)
No. of teeth, dentates only		25.5 (25.3; 25.7)	26.1 (26.0; 26.3)	26.6 (26.5; 26.8)	18.3 (17.9; 18.8)	19.7 (19.3; 20.1)	20.7 (20.2; 21.2)
No. of crowned teeth, dentates only		5.0 (4.8; 5.3)	3.8 (3.6; 4.0)	1.5 (1.3; 1.6)	6.7 (6.4; 7.0)	7.6 (7.3; 7.9)	7.1 (6.7; 7.4)
Percentage of crowned teeth, dentates only (%)		21.2 (20.1; 22.3)	15.5 (14.7; 16.4)	5.9 (5.1; 6.8)	42.2 (40.1; 44.3)	43.0 (41.2; 44.6)	38.1 (36.0; 40.1)
No. of interdentally filled teeth, dentates only		6.4 (6.2; 6.7)	5.8 (5.6; 6.1)	3.3 (3.0; 3.5)	4.0 (3.8; 4.3)	4.1 (3.9; 4.3)	3.4 (3.1; 3.6)
Percentage of interdentally filled teeth, dentates only (%)		25.0 (24.1; 25.9)	22.5 (21.6; 26.5)	12.4 (11.6; 13.3)	20.6 (19.6; 21.7)	19.3 (18.5; 20.1)	15.5 (14.4; 16.6)
The following data refer to a maximum of 12 index teeth and 36 sites with periodontal examinations							
No. of periodontally examined index teeth		10.4 (10.3; 10.5)	10.8 (10.7; 10.9)	11.2 (11.1; 11.3)	6.6 (6.4; 6.8)	7.2 (7.0; 7.4)	8.1 (7.8; 8.3)
Mean PD, mm		2.4 (2.3; 2.4)	2.4 (2.3; 2.4)	2.3 (2.3; 2.4)	2.8 (2.8; 2.9)	2.8 (2.8;2.9)	2.8 (2.7; 2.9)
No. of teeth with PD ≤ 3 mm		6.9 (6.7; 7.2)	8.1 (7.9; 8.3)	8.4 (8.2; 8.7)	3.1 (2.9; 3.3)	4.1 (3.9; 4.3)	4.6 (4.4; 4.9)
No. of teeth with PD 4–5 mm		3.0 (2.8; 3.1)	2.4 (2.3; 2.6)	2.5 (2.3; 2.6)	2.7 (2.5; 2.8)	2.6 (2.4; 2.7)	2.7 (2.6; 2.9)
No. of teeth with PD ≥ 6 mm		0.5 (0.4; 0.6)	0.3 (0.2; 0.3)	0.3 (0.2; 0.4)	0.8 (0.7; 0.9)	0.5 (0.4; 0.6)	0.7 (0.6; 0.8)
Percentage of sites with PD ≥ 4 mm (%)		16.0 (14.9; 17.1)	13.0 (11.9; 14.2)	11.8 (10.7; 12.8)	28.1 (26.6; 29.7)	26.4 (24.6; 28.2)	24.2 (22.5; 25.9)
Percentage of sites with PD ≥ 6 mm (%)		2.0 (1.6; 2.3)	1.1 (0.8; 1.4)	1.2 (0.9; 1.5)	5.5 (4.7; 6.3)	3.7 (3.0; 4.3)	4.3 (3.6; 5.0)
Community Periodontal Index	Score 0–2 (equals prevalence of max PD ≤ 3 mm)	23.4% (20.7; 26.2)	40.8% (37.7; 43.9)	33.1% (30.1; 36.2)	10.2% (8.4; 12.1)	21.2% (18.8; 23.8)	14.8% (12.4; 17.5)
	Score 3 (equals prevalence of max PD 4–5 mm)	55.6% (52.4; 58.8)	47.7% (44.6; 50.9)	54.7% (51.4, 57.9)	37.5% (34.5; 40.5)	44.4% (41.4; 47.5)	49.4% (45.8; 53.0)
	Score 4 (equals prevalence of max PD ≥ 6 mm)	20.0% (17.5; 22.7)	10.7% (8.9; 12.8)	12.2% (10.2; 14.5)	29.1% (26.4; 31.9)	21.7% (19.2; 24.3)	30.4% (27.1; 33.7)
	Edentulous	1.0% (0.5; 1.8)	0.8% (0.3; 1.4)	0.1% (0.0; 0.5)	23.2% (20.7; 25.8)	12.7% (10.7; 14.8)	5.4% (3.9; 7.2)
The following data refer to a maximum of 28 teeth in individuals with CPI scores							
No. of teeth (max. 28) for individuals with a CPI score of	0–2	25.9 (25.4; 26.3)	26.6 (26.4; 26.8)	27.1 (26.9; 27.3)	15.6 (14.2; 17.1)	18.3 (17.3; 19.3)	20.0 (18.7; 21.4)
	3	25.6 (25.4; 25.9)	25.8 (25.6; 26.1)	26.5 (26.3; 26.7)	18.2 (17.5; 18.9)	20.1 (19.6; 20.7)	20.8 (20.1; 21.4)
	4	24.7 (24.2; 25.2)	25.7 (25.2; 26.3)	25.9 (25.3; 26.6)	19.5 (18.8; 20.2)	20.2 (19.4; 21.0)	21.0 (20.2; 21.8)

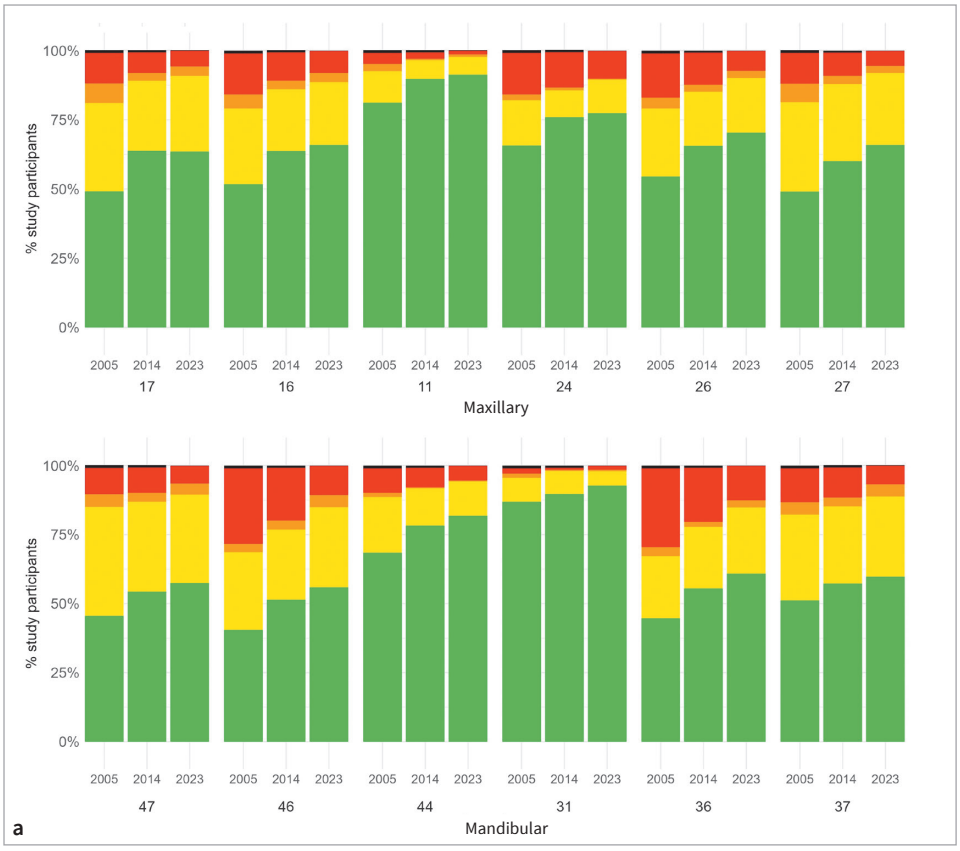
Data are presented as weighted percentages or weighted means (with 95% confidence intervals) for edentate and dentate participants with complete periodontal findings (partial recording protocol: 12 index teeth with 3 sites).
CPI, Community Periodontal Index; PD, probing depth.

All analyses were conducted using Stata/MP 18.0 (StataCorp 2023). *P* values < .05 were considered statistically significant. The recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were applied for reporting.[9]

Data handling and statistical methods, including statistical methods for trend analysis, have been described previously.[10]

Results

The proportion of younger adults and younger seniors with higher school education increased from 32.2% to 59.2% for younger adults and from 17.0% to 38.4% for younger seniors (Table 1). Conversely, the proportion of younger adults with low educational attainment decreased by 12% points, while



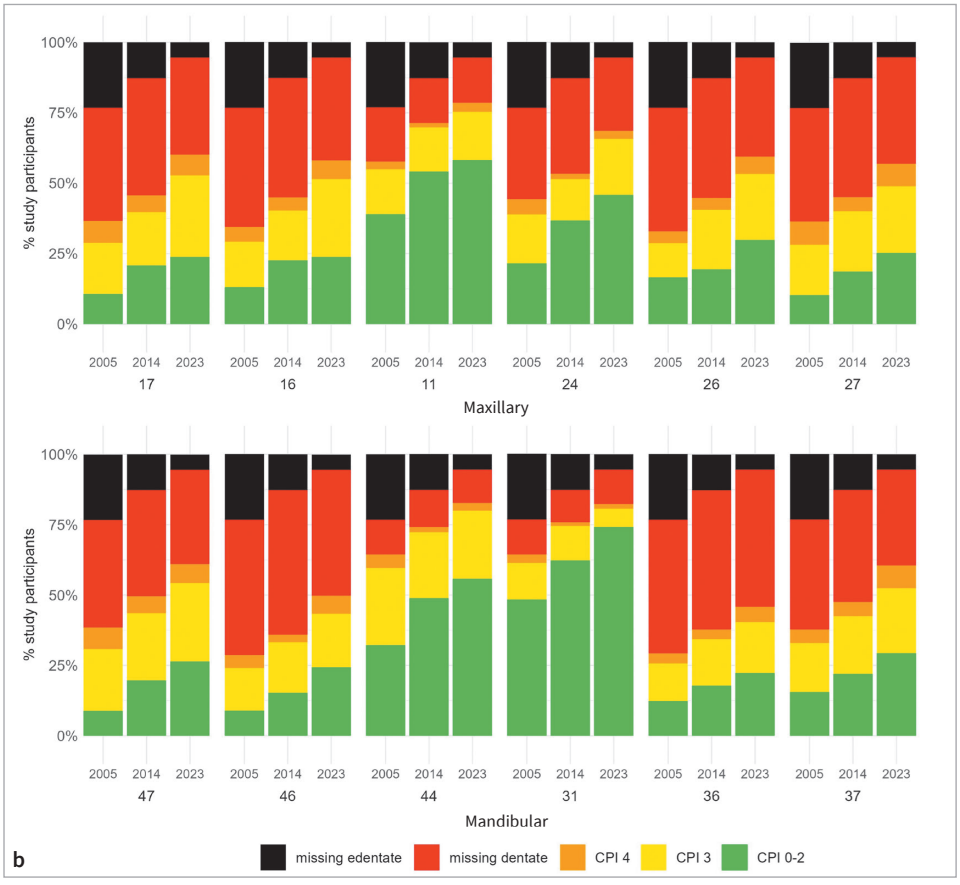


Fig 1a and b Percentage of edentates (black), missing teeth (red), and present teeth with maximum probing depths ≥ 6 mm/CPI 4 (orange), 4–5 mm/CPI 3 (yellow), and 1–3 mm/CPI 0–2 (green) for each index tooth in the maxilla and mandible for younger adults (35- to 44-year-olds) *(a)* and younger seniors (65- to 74-year-olds) *(b)* in DMS IV (2005), DMS V (2014), and DMS • 6 (2023), based on weighted data.

among younger seniors it decreased by approximately 40% points. The proportion of those who have never smoked increased by approximately 10% points among younger adults from DMS IV to DMS • 6, whereas it decreased from 61.8% to 48.9% among younger seniors. Neither the BMI (approximately 26 for younger adults and 27 for younger seniors) nor the percentage of diabetics (2% for younger adults and 16% for younger seniors) exhibited any change across the waves. More than 80% of both younger adults and younger seniors reported brushing their teeth at least twice daily. At DMS IV, 55% of younger adults and 33% of dentate younger seniors utilized an interdental cleaning device, with an upward trend in usage. The utilization of electric toothbrushes demonstrated an upward trajectory from DMS IV to DMS • 6, with an increase from 37.5% to 55.6% among younger adults and 17.2% to 51.4% among younger seniors. Approximately 90% of younger adults and younger seniors reported visiting a dental practitioner at least once a year. There was a notable decline in the proportion of younger adults (from 24.3% to 12.4%) and younger seniors (from 38.9% to 31.9%) who reported lifetime periodontal treatment.

The proportion of edentate participants exhibited a notable decline, from 1.0% to 0.1% for younger adults and 23.2% to 5.4% for younger seniors, between DMS IV and DMS • 6 (Table 2). Consequently, dentate younger adults had on average 1.1 more teeth in DMS • 6 compared to their DMS IV counterparts, while dentate younger seniors had 2.4 more teeth. The mean PD remained largely unchanged across the three waves, with a mean of 2.4 mm for younger adults and 2.8 mm for younger seniors. Although the number of teeth increased in both groups, the average number of teeth with PDs of 4 to 5 mm or ≥ 6 mm decreased markedly from DMS IV to DMS V. This decrease was observed in both younger adults (from 3.5 to 2.7) and younger seniors (from 3.5 to 3.1). No significant changes were observed from DMS V to DMS • 6 in either group. A comparable trend was identified in the number of teeth exhibiting PDs of 6 mm or greater in younger adults. In contrast, among younger seniors, this number demonstrated a decline from DMS IV to DMS V, followed by an increase by DMS • 6. The percentage of participants with CPI scores of 0 to 2 increased between DMS IV and DMS • 6, from 23.4% to 33.1% in younger adults and 10.2% to 14.8% in younger seniors. In younger adults grouped according to categories defined by CPI (Table 2, bottom rows), the total number of teeth exhibited an approximate increase of 1 between DMS IV and DMS • 6. For younger seniors with a CPI of 0 to 2, 3, or 4, the number of teeth demonstrated an increase of 4.4, 2.6, and 1.5 teeth, respectively, between DMS IV and DMS • 6.

Figure 1 shows the distribution of CPI scores and missing teeth in edentate and dentate individuals for each of the 12 index teeth. In younger adults and younger seniors, molars contributed more to the increased number of retained teeth than single-rooted teeth. The percentage of participants with a natural tooth (green, yellow, orange) increased linearly across waves for all age groups and tooth positions, with single-rooted teeth having higher baseline levels than molars. The proportion of younger adults with CPI scores of 0 to 2 increased between DMS IV and DMS V for all tooth positions, whereas the proportion of younger adults with CPI scores of 4 decreased for all tooth positions. The distribution of younger adults according to their CPI scores and tooth loss status for all tooth positions exhibited minimal variation between DMS V and DMS • 6. In all tooth positions, the proportion of younger seniors with CPI scores of 0 to 2 increased across all teeth and all waves. Only for molars did the proportion of younger seniors with CPI scores of 3 to 4 increase from DMS IV to DMS V and from DMS V to DMS • 6.

Finally, observed changes in tooth counts between consecutive DMS studies were decomposed into those attributable to differences in distributions of independent variables (ie, differences in characteristics) and those attributable to differences in associations of independent variables with tooth count variables (ie, differences in coefficients; Table 3). In younger adults, differences in characteristics accounted for 28.1% and 31.2% of the observed study differential in the number of missing teeth between DMS IV and DMS V (−0.786) and between DMS V and DMS • 6 (−0.510), respectively. Most of the observed reduction in the number of missing teeth was explained by an increase in the proportion of highly educated younger adults (beta −0.140 and −0.118) and an increase in the proportion of those who had never smoked (beta −0.016 and −0.069). The increase in the proportion of individuals using electric toothbrushes (beta −0.035 and −0.023) and interdental cleaning devices (beta −0.035 and −0.022) and the reduction in the proportion of individuals with lifetime periodontal treatment (beta −0.045 and −0.026) were also identified as contributing factors. In dentate younger seniors, differences in characteristics accounted for 26.2% and 67.6% of the observed differences in the prevalence of having less than 20 teeth between DMS IV and DMS V (−0.109) and between DMS V and DMS • 6 (−0.076), respectively. Most of this reduction was attributable to an increase in the proportion of highly educated younger seniors (beta −0.007 and −0.014), an increase in the proportion of former smokers (betas −0.004), an increase in the proportion of individuals using electric toothbrushes (beta −0.012 and −0.020) and interdental cleaning devices (beta −0.018 and −0.012), and a reduction in the proportion of individuals with lifetime periodontal treatment (DMS IV to DMS V only; beta −0.018). In dentate and edentate

Table 3a Results from multivariate decomposition models for dentate younger adults (35- to 44-year-olds; dependent variable: "number of missing teeth"; Poisson models)

					Decomposition for "Number of missing teeth"	
					DMS IV to DMS V	DMS V to DMS • 6
Difference					−0.786	−0.510
Due to difference in characteristics					−0.221 (28.1%)	−0.159 (31.2%)
Due to difference in coefficients					−0.566 (71.9%)	−0.351 (68.8%)
		Observed means and percentages*			Model for differences in characteristics	
		DMS IV	DMS V	DMS • 6	Coefficient	Coefficient
Age, years		39.0	39.8	40.1	0.088	0.018
Gender (ref. female)	Male	43.5%	46.7%	49.6%	−0.024	−0.010
School education (ref. < 10 years)	10 years	45.9%	40.5%	31.1%	0.020	0.045
	> 10 years	32.9%	43.6%	59.5%	−0.140	−0.118
Smoking status (ref. current smokers)	Former smokers	19.7%	24.8%	20.1%	−0.030	0.045
	Never smoked	45.3%	47.4%	54.9%	−0.016	−0.069
Body mass index, kg/m²		25.6	25.9	26.2	0.009	0.001
Diabetes mellitus (ref. no)	Yes	NA	1.8%	2.3%	NA	0.001
Tooth brushing frequency (ref. ≥ 2 times daily)	< 2 times daily	14.8%	16.9%	17.4%	−0.003	0.000
Electric toothbrush utilization (ref. no)	Yes	38.2%	48.5%	56.6%	−0.035	−0.023
Interdental cleaning aids utilization (ref. no)	Yes	56.2%	63.1%	68.2%	−0.035	−0.022
Dental visits frequency (ref. rarely)	≥ once a year	90.9%	87.4%	87.9%	−0.009	0.000
Lifetime periodontal treatment (ref. no)	Yes	24.3%	19.7%	13.2%	−0.045	−0.026

*Including only individuals from multivariate decomposition models.
Red text, positive statistically significant beta coefficients; Green text, negative statistically significant beta coefficients.
NA, not available.

Table 3b Results from multivariate decomposition models for dentate younger seniors (65- to 74-year-olds; dependent variable: "having less than 20 teeth"; coded as yes/no; logistic models)

					Decomposition for "Having less than 20 teeth"	
					DMS IV to DMS V	DMS V to DMS • 6
Difference					−0.109	−0.076
Due to difference in characteristics					−0.029 (26.2%)	−0.051 (67.6%)
Due to difference in coefficients					−0.081 (73.8%)	−0.025 (32.4%)
		Observed means and percentages*			Model for differences in characteristics	
		DMS IV	DMS V	DMS • 6	Coefficient	Coefficient
Age, years		68.6	69.3	69.7	0.008	0.004
Gender (ref. female)	Male	48.0%	46.8%	45.5%	0.001	0.001
School education (ref. < 10 years)	10 years	20.1%	28.4%	37.6%	−0.008	0.001
	> 10 years	20.5%	28.7%	40.4%	−0.007	−0.014
Smoking status (ref. current smokers)	Former smokers	31.0%	33.7%	37.7%	−0.004	−0.004
	Never smoked	62.1%	56.0%	50.6%	0.012	0.008
Body mass index, kg/m²		27.3	27.1	27.2	−0.0003	0.001
Diabetes mellitus (ref. no)	Yes	14.2%	14.9%	15.3%	0.001	0.0001
Tooth brushing frequency (ref. ≥ 2 times daily)	< 2 times daily	16.0%	15.5%	16.0%	0.001	0.0001
Electric toothbrush utilization (ref. no)	Yes	21.8%	37.7%	51.5%	−0.012	−0.020
Interdental cleaning aids utilization (ref. no)	Yes	42.2%	56.2%	64.8%	−0.018	−0.012
Dental visits frequency (ref. rarely)	≥ once a year	90.2%	91.8%	90.1%	−0.002	0.002
Lifetime periodontal treatment (ref. no)	Yes	42.2%	41.7%	31.5%	−0.00002	−0.018

*Including only individuals from multivariate decomposition models.
Red text, positive statistically significant beta coefficients; Green text, negative statistically significant beta coefficients.

Table 3c Results from multivariate decomposition models for dentate and edentate younger seniors (65- to 74-year-olds; dependent variable: "having less than 20 teeth"; coded as yes/no; logistic models)

					Decomposition for "Having less than 20 teeth"	
					DMS IV to DMS V	DMS V to DMS • 6
Difference					−0.150	−0.102
Due to difference in characteristics					−0.021 (14.2%)	−0.034 (33.9%)
Due to difference in coefficients					−0.129 (85.8%)	−0.067 (66.1%)
		Observed means and percentages*			Model for differences in characteristics	
		DMS IV	DMS V	DMS • 6	Coefficient	Coefficient
Age, years		68.8	69.3	69.7	0.009	0.006
Gender (ref. female)	Male	47.0%	46.8%	46.1%	0.0003	0.0003
School education (ref. < 10 years)	10 years	17.7%	27.3%	37.2%	−0.013	−0.005
	> 10 years	17.3%	26.7%	39.1%	−0.015	−0.024
Smoking status (ref. current smokers)	Former smokers	29.9%	35.1%	38.1%	−0.009	−0.004
	Never smoked	61.9%	52.9%	48.8%	0.025	0.009
Body mass index, kg/m²		27.4	27.3	27.3	−0.001	−0.0002
Diabetes mellitus (ref. no)	Yes	16.0%	15.9%	15.8%	−0.0001	−0.00001
Dental visits frequency (ref. rarely)	≥ once a year	80.8%	89.5%	89.0%	−0.019	0.001
Lifetime periodontal treatment (ref. no)	Yes	38.7%	41.7%	32.1%	0.0001	−0.016

*Including only individuals from multivariate decomposition models.
Red text, positive statistically significant beta coefficients; Green text, negative statistically significant beta coefficients.

younger seniors, 14.2% and 33.9% of the study differentials were attributed to differences in characteristics, in particular, school education, former and never smoking, and frequency of dental visits. More detailed results from multivariate decomposition models are given as additional material (Appendix 1).

Discussion

The oral health situation in Germany has improved significantly over the past two decades. There has been a notable decline in the number of edentate individuals and an increase in the average number of teeth. On initial examination, the trends in the periodontal status appear to exhibit a perplexing array of inconsistencies, lacking discernible patterns. The proportion of younger adults with CPI scores of 4 halved between DMS IV and DMS V, subsequently stabilizing at 11% to 12%. Conversely, the proportion of younger seniors with CPI scores of 4 decreased from 29.1% to 21.7% and then increased to 30% in DMS • 6. An analysis of the extent of PD ≥ 6 mm at either site or tooth level, as opposed to prevalences, corroborates this finding. It should be noted, however, that the commonly reported CPI scores (ie, scores 3 and 4) do not focus on periodontal health. Indeed, the prevalence of CPI scores 0 to 2 exhibited an increase from 23.4% to 33.1% in younger adults and from 10.2% to 14.8% in younger seniors. Furthermore, there has been a notable increase in the proportion of individuals displaying CPI scores between 0 and 2 for all tooth positions, both in younger adults and younger seniors. This increase has been observed across the transition periods from DMS IV to DMS V and from DMS V to DMS • 6 (Fig 1). Therefore, if the conclusion is based on CPI scores of 0 to 2 rather than CPI scores of 3 or 4, it can be concluded that the periodontal health of the population has improved. If it is based on a CPI score of 4, differentiation between younger adults and younger seniors is needed, and it should be acknowledged that from DMS V to DMS • 6, periodontitis plateaued in younger adults, but worsened in younger seniors.

Another rationale for enhanced periodontal health is the increase in tooth counts observed across all CPI categories. It remains to be seen whether this observation signifies a shift in dental practice, whereby practitioners alter their approach to extraction and opt to treat and retain severely periodontally compromised teeth.[11] A similar result was observed in the Jönköping studies.[12] The improvement in dental health also resulted in a notable increase in the number of teeth in individuals with severe periodontitis. Yet, disparities in the number of teeth across disease categories persisted.

At the tooth level, the molars exhibited a more pronounced degree of improvement than single-rooted teeth. Therefore, the observed improvement may have been overestimated at the subject level due to the overrepresentation of molars among the index teeth. As molars are typically more susceptible to periodontitis, the notable increase in the percentage of periodontally healthy molars indicates a notable decrease in periodontal risk. Furthermore, the rebound in the prevalence of CPI score 4 in younger seniors from DMS V to DMS • 6 may be attributed to more retained molars in comparison to single-rooted teeth.

In response to the question posed by the health authorities regarding the impact of retaining more teeth on the need for treatment (as defined by the presence of PDs ≥ 4 mm), the present findings indicate that in younger adults, the necessity for treatment decreased in both molars and single-rooted teeth. Conversely, in younger seniors, the necessity for treatment increased in molars but decreased in single-rooted teeth. In parallel with the improvement in the periodontal status in both age groups, the proportion of individuals reporting lifetime periodontal treatment decreased from 24% to 12% in younger adults and from 39% to 32% in younger seniors. This decrease might be explained by the increase in the number of periodontally healthy individuals and a reduction in the need for periodontal treatment. Furthermore, more participants in later waves were highly educated, which may have facilitated a more comprehensive understanding of the contents of periodontal treatment. The level of knowledge of the German population regarding periodontal health and treatment used to be low.[13] In earlier waves, participants may have incorrectly identified professional tooth cleaning as periodontal treatment, which could account for the higher prevalence observed in earlier waves. Furthermore, the reduction in the proportion of individuals reporting lifetime periodontal treatment was identified as a contributing factor to the observed decrease in the number of missing teeth across waves (Table 3). This finding aligns with previous research, which demonstrated that tooth loss rates were notably higher in periodontally treated patients than in untreated SHIP-TREND (Study of Health in Pomerania) participants with moderate to severe periodontitis.[14] Higher rates of tooth loss observed during periodontal treatment may be attributable to inadequate oral hygiene instruction or the inefficacy of nonsurgical periodontal treatment. In addition, less effort was made to retain questionable or hopeless teeth during active periodontal therapy in the earlier waves.

Finally, there was no information as to whether participants were enrolled in a structured maintenance program (supportive periodontal care; SPC), which is key to the long-term success of periodontal treatment.[15] SPC was not part of treatment covered by statutory insurance in Germany until July 2021.

The most reliable proxy for lifetime dental problems is edentulism. In all high-income countries, the prevalence of edentulism has been declining and there has been an increase in the number of teeth retained. In numerous epidemiologic studies, edentulism has not been included in the denominator used to calculate the prevalence of periodontitis in a population.[16] In previous DMS publications, the prevalence of periodontitis was only reported for dentate individuals.[7,17,18] However, to accurately estimate the prevalence of periodontitis in the general population, it is essential to consider the data on edentulism. If it is assumed that 40% of the population is edentulous and 18% of dentate individuals have periodontitis, the actual prevalence of periodontitis in the population is 10.8%.

The Jönköping studies revealed that the proportion of individuals with severe periodontitis remained constant over a period of five decades. However, the proportion of edentate individuals decreased to zero.[12] It was hypothesized that a transition from edentulism to severe periodontitis, and from severe to healthy/moderate periodontitis had occurred at comparable rates. Similar observations have been made in other repeated cross-sectional studies (USA, Spain, Japan, New Zealand).[19] Also, in DMS, the decrease in the prevalence of edentulism or in the number of missing teeth in dentate younger seniors led to an increase in the prevalence of the CPI scores of 0 to 3, while the prevalence of CPI scores of 4 remained constant.

As with other high-income countries, Germany has experienced notable shifts in the prevalence of upstream health determinants over the past three decades: the proportion of individuals with higher education has increased, the prevalence of tobacco consumption has declined,[20] and the prevalence of diabetes has increased.[21] With regard to downstream determinants, the present findings indicate a notable increase in the utilization of electric toothbrushes and interdental cleaning aids.[22] From the perspective of health planners, education is considered to be the most important factor with a positive impact on oral health.[22] In addition to education, the increased use of interdental cleaning devices and electric toothbrushes has contributed to the increase in the number of teeth.[3] In the DMS studies, the decline in the number of missing teeth among younger adults and younger seniors between DMS IV and DMS V and between DMS V and DMS • 6 was found to be mainly attributable to an increase in the proportion of individuals with high education status, an increase in the proportion of those who have never smoked (younger adults only), and an increase in the use of electric toothbrushes and interdental

cleaning aids. Thus, population preventive measures were largely responsible, including, for example, smoking bans. In light of these findings, the present authors conclude that the dental community should promote using electric toothbrushes and interdental cleaning aids and encourage patients to quit smoking.

It is important to consider some methodologic issues as a limitation of the present study. Firstly, in DMS IV and DMS V, a WHO periodontal probe with markings at 3.5, 5.5, 8.5, and 11.5 mm was utilized, whereas in DMS • 6 a probe with 1-mm increments was employed. Therefore, an overrepresentation of PD measurements coinciding with probe graduation markings is likely to have occurred in DMS IV and DMS V. This phenomenon is referred to as digit preference.[23] Secondly, as molars are overrepresented among index teeth, the prevalence of periodontitis is probably overestimated. To obtain unbiased full-mouth estimates of periodontitis prevalence in DMS • 6, please refer to Eickholz et al.[24]

Conclusion

Oral health has improved significantly over the past two decades, with the greatest improvements in periodontal health between 2005 and 2014. The reduction in the number of missing teeth was mainly attributed to positive trends in education, smoking, and oral hygiene care. This underscores the importance of preventive measures, which should be repeatedly reinforced in the dental office or through industry advertising as a public health approach.

Disclosure

ARJ, DS, and KK are employed at the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfil the criteria for authorship according to the Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. TK is a member of the DMS • 6 scientific advisory board, responsible for developing the clinical examinations, and the author of the manuscript. PE is a member of the DMS • 6 scientific advisory board, responsible for developing the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. DS and VP were jointly responsible for statistical data preparation and analysis. BH is a scientific advisor for the DMS • 6 and a co-author of the manuscript.

References

1. Kocher T, Holtfreter B, Pitchika V, Kuhr K, Jordan AR. Entwicklung der Zahn- und Mundgesundheit in Deutschland von 1997 bis 2014. Bundesgesundheitsbl 2021;64: 782–792.
2. Zentrum für Krebsregisterdaten. Lungenkrebs (Bronchialkarzinom); 2023 [updated 07.12.2023]. https://www.krebsdaten.de/Krebs/DE/Content/Krebsarten/Lungenkrebs/lungenkrebs_node.html.
3. Pitchika V, Jordan AR, Micheelis W, Welk A, Kocher T, Holtfreter B. Impact of powered toothbrush use and interdental cleaning on oral health. J Dent Res 2021;100:487–495.
4. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.
5. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl): S14–S21.
6. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006.
7. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.
8. Bauer TK, Sinning M. An extension of the Blinder-Oaxaca decomposition to nonlinear models. Adv Stat Analys 2008;92:197–206.
9. Elm E von, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg 2014;12:1495–1499.
10. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

11. Rug J, Holtfreter B, Völzke H, Kocher T. Have extraction patterns in German adults with severe periodontitis changed between 2000 and 2010? Results from two cohort studies. J Clin Periodontol 2023;50:463–475.

12. Wahlin Å, Papias A, Jansson H, Norderyd O. Secular trends over 40 years of periodontal health and disease in individuals aged 20–80 years in Jönköping, Sweden: Repeated cross-sectional studies. J Clin Periodontol 2018;45:1016–1024.

13. Deinzer R, Micheelis W, Granrath N, Hoffmann T. More to learn about: periodontitis-related knowledge and its relationship with periodontal health behaviour. J Clin Periodontol 2009;36:756–764.

14. Kocher T, Holtfreter B, Priess H-W, et al. Tooth loss in periodontally treated patients: a registry⊠ and observation⊠based analysis. J Clin Periodontol 2022;49:749–757.

15. Heasman PA, McCracken GI, Steen N. Supportive periodontal care: the effect of periodic subgingival debridement compared with supragingival prophylaxis with respect to clinical outcomes. J Clin Periodontol 2002;29(Suppl 3):163–172.

16. Trindade D, Carvalho R, Machado V, Chambrone L, Mendes JJ, Botelho J. Prevalence of periodontitis in dentate people between 2011 and 2020: A systematic review and meta⊠analysis of epidemiological studies. J Clin Periodontol 2023;50:604–626.

17. Schützhold S, Kocher T, Biffar R, et al. Changes in prevalence of periodontitis in two German population-based studies. J Clin Periodontol 2015;42:121–130.

18. Micheelis W. Zusammenfassung/Abstract. In: Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006:17–21.

19. Kocher T, Meisel P, Baumeister S, Holtfreter B. Impact of public health and patient-centered prevention strategies on periodontitis and caries as causes of tooth loss in high-income countries (Epub ahead of print, 25 Sep 2024). Periodontology 2000 doi: 10.1111/prd.12592.

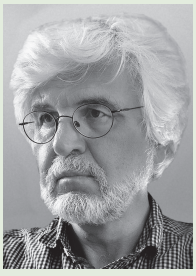
20. Zeiher J, Finger JD, Kuntz B, Hoebel J, Lampert T, Starker A. Zeitliche Trends beim Rauchverhalten Erwachsener in Deutschland: Ergebnisse sieben bundesweiter Gesundheitssurveys 1991–2015. Bundesgesundheitsbl 2018;61:1365–1376.

21. Tönnies T, Röckl S, Hoyer A, et al. Projected number of people with diagnosed Type 2 diabetes in Germany in 2040. Diabet Med 2019;36:1217–1225.

22. Pitchika V, Jordan AR, Norderyd O, et al. Factors influencing tooth loss in European populations. J Clin Periodontol 2022;49:642–653.

23. Holtfreter B, Alte D, Schwahn C, Desvarieux M, Kocher T. Effects of different manual periodontal probes on periodontal measurements. J Clin Periodontol 2012;39:1032–1041.

24. Eickholz P, Holtfreter B, Kuhr K, Dannewitz B, Jordan AR, Kocher T. Prevalence of the periodontal status in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S40–S47.



Thomas Kocher

Peter Eickholz Chair, Department of Periodontology, Center of Dentistry and Oral Medicine (Carolinum), Johann Wolfgang Goethe University, Frankfurt/Main, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Dominic Sasunna Data manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Vinay Pitchika Research Associate, Department of Conservative Dentistry and Periodontology, LMU Hospital, Munich, Germany.

Thomas Kocher Senior Professor, Department of Restorative Dentistry, Periodontology and Endodontology, University Medicine Greifswald, Greifswald, Germany

Birte Holtfreter Senior Researcher, Department of Restorative Dentistry, Periodontology and Endodontology, University Medicine Greifswald, Greifswald, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

Appendix 1

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/trends-in-periodontal-status-results-from-the-german-oral-health-studies-from-2005-to-2023-online-appendix/.

Tooth loss and denture status: results of the 6th German Oral Health Study (DMS • 6)

Bernd Wöstmann*, Prof Dr med dent/Stefanie Samietz*, Priv-Doz Dr med dent, MPH, MSc/A. Rainer Jordan, Prof Dr med dent, MSc/Kathrin Kuhr, Dr rer medic/Ina Nitschke#, Prof Dr med dent, MPH/Helmut Stark#, Prof Dr med dent

Objectives: The German Oral Health Study (DMS) is a series of consecutive studies designed to assess the oral health status of adults, seniors, and children in Germany. DMS is a major program of the Institute of German Dentists (Institut der Deutschen Zahnärzte) with the aim to produce health statistics for Germany. Tooth loss, edentulism, and prosthetic care have considerable socioeconomic significance; it is the aim of this paper to report findings on these aspects. **Method and materials:** The survey combines interviews and clinical examinations. Previous DMS studies focused primarily on tooth loss, edentulism, and prosthetic care. In the DMS • 6 survey, the condition of removable dentures and need for adjustments were additionally recorded, as well as necessary repair measures that were grouped according to their complexity (chairside or laboratory). **Results:** The prevalence of edentulism decreased considerably compared to that in the Fifth German Oral Health Study (DMS V) in 2014. Among younger adults (35- to 44-year-olds), the prevalence of edentulism was negligible, with an average of 26.6 teeth present. The younger senior group (65- to 74-year-olds) had an average of 19.3 teeth; the prevalence of edentulism was 5%, which is a reduction of > 50% compared to 2014 (12.4%). Lower education status was an important prognostic factor for tooth loss. Owing to the low prevalence of edentulism in younger adults, removable dentures were not prevalent in this age group, whereas combined fixed–removable dentures were most frequently used in seniors. Regarding the type of denture, a shift towards fixed as well as implant-supported types was observed. Of the removable dentures, 50% to 60% were in a very good or good clinical condition. Problems were mainly identified with simple acrylic dentures. Nonetheless, participants' satisfaction with removable dentures was extremely high, and the dentures were used almost continuously. **Conclusion:** The most important finding in this study is the continued significant decline in the prevalence of complete edentulism among seniors that suggests a further reduction in edentulism in the future with an estimate of around 4% in 2030. The shift observed in primary prosthetic care from removable to fixed prostheses as well as the increasing prevalence of implants placed are positive developments. The data revealed further compression of morbidity compared to DMS V. Complete edentulism declined, and fixed partial dentures, including implant-supported prostheses, were increasingly used. Lower education status was an important predictor for tooth loss. *(Quintessence Int 2025;56(Suppl):S60–S68; doi: 10.3290/j.qi.b5986257)*

Keywords: dental care, dental prostheses, dentists, DMS 6, edentulous mouth, epidemiology, tooth loss

Replacement of missing teeth in completely or partially edentulous patients has considerable economic implications. German public health insurance expenditure on denture treatment in 2023 was €4.02 billion.[1] In the 6th German Oral Health Study (DMS • 6), the benefits of prevention-oriented dentistry in childhood were observed in younger adults (35- to 44-year-olds); however, similar benefits were only observed in exceptional cases in the senior group (65- to 74-year-olds).

The German Oral Health Study (DMS) is a series of consecutive epidemiologic studies designed to assess the oral health status of adults, seniors, and children in Germany. The Institute of German Dentists (Institut der Deutschen Zahnärzte) has surveyed the oral health of the German population (DMS I/II–V) since 1989.[2,3] In these studies, in addition to the dental status, data on removable dentures were collected, and the prevalence of the individual treatment modalities was analyzed. In

addition, the treatment needs for removable and combined fixed–removable dentures were assessed, and four categories were defined (no need for treatment, new restoration necessary, repair necessary due to technical defects, and relining necessary due to alveolar ridge atrophy).[4] In DMS • 6, the criteria regarding removable dentures were further refined, and the denture condition was evaluated in addition to denture related need for treatment. Furthermore, necessary repairs were classified according to their extent and complexity (repairs that can be carried out chairside and those that require dental laboratory support).

The part of the DMS • 6 survey described here aimed—in continuation of the previous DMS studies—to produce health statistics for Germany with regard to tooth loss, edentulism, prosthetic care, and treatment need with education status as a covariate.

Method and materials

The general methodology of the study is presented in separate articles.[5,6] The 6th German Oral Health Study (DMS • 6) has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

The study included 927 younger adults (35- to 44-year-olds) and 797 younger seniors (65- to 74-year-olds) who fulfilled the inclusion criteria of DMS • 6.

Measurement methods and variables

Regarding refinement of the criterion "Treatment need for removable dentures," the challenge was to develop an assessment structure that was easy to use and standardized for the different types of dentures. It had to be largely comparable with those in previous studies and fit into the limited time frame of a field study. Therefore, the following four-stage protocol originally described by Marxkors was used[7]:

1. No deficiencies, very good quality: Protection of the teeth and of adjacent tissues is warranted; no deviation from the ideal.
2. Acceptable condition, good quality: Minor deviations from the ideal that need to be corrected and monitored. Corrections can be carried out chairside.
3. Moderate deficiencies, moderate quality: These require correction with the assistance of a dental technician in a dental laboratory. After correction, the denture is acceptable and can be used further.
4. Major deficiencies, poor quality: The existing deficiencies can only be corrected by fabricating a new removable or combined fixed–removable denture.

Levels 1 and 2 describe restorations that are completely or mostly functional and can be corrected chairside by simple measures, if necessary. In contrast, levels 3 and 4 include restorations that require major corrections or fabrication of a new denture.

This protocol is comparable with that used in DMS V, because levels 1 and 4 correspond to those in DMS V, and the groups "relining" and "repair" from DMS V correspond to level 3.[2]

Similar to that in DMS IV and V, the concept of primary restoration was used to characterize the overall prosthodontic status.[8] Participants were categorized into groups based on the type of denture replacing the largest number of teeth, independent of the jaw. A total of six consecutive categories were defined:

- fully dentate without gaps and without dentures
- at least one untreated gap, no dentures
- at least one crown restoration
- at least one fixed denture (ie, bridge/implant)
- at least one removable partial denture
- at least one complete denture.

Statistical analysis

For the epidemiologic description, prevalences and means with associated 95% confidence intervals (CIs) were calculated separately for younger adults and younger senior groups. A weighted dataset was used for this purpose to compensate for selection bias and differences in gender, age, and region compared to the overall population in Germany. Numbers (n) are provided without weighting. Within the age groups, subgroup analyses were conducted based on gender (male/female) and education group (low/medium/high). Detailed information on data handling and statistical methods is described previously.[9]

Results

Tooth loss and complete edentulism

The declining prevalence of tooth loss observed in DMS V[2,3] continued in the newly collected data. In previous DMS, complete

Table 1 Epidemiologic description and treatment of missing teeth in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) by gender

Variable		35- to 44-year-olds			65- to 74-year-olds		
			Gender			Gender	
		Total	Male	Female	Total	Male	Female
No. of participants (n)		927	459	467	797	375	422
Full dentition (base 28 teeth, prevalence)		56.3%	57.1%	55.3%	6.7%	7.9%	5.5%
Edentulism (base 32 teeth, prevalence)	Maxilla only	0.1%	0.2%	0.0%	10.8%	12.2%	9.4%
	Mandible only	0.2%	0.1%	0.3%	7.2%	8.1%	6.4%
	Total	0.1%	0.1%	0.0%	5.0%	6.4%	3.8%
Number of missing teeth (base 28 teeth)	Total	1.4	1.4	1.4	8.7	8.8	8.7
	Not replaced	0.9	0.9	0.9	2.0	2.0	2.0
	Replaced by pontics	0.2	0.2	0.2	1.5	1.4	1.7
	Replaced by removable dentures	0.1	0.2	0.1	4.5	4.6	4.3
	Replaced by implants	0.1	0.1	0.1	0.7	0.8	0.6
Percentage of missing teeth that have been replaced (%)		28.1	25.1	30.9	63.8	61.7	65.7

Data are presented as unweighted numbers (n) and weighted percentages or weighted means. One gender-diverse individual is included in the total column, but not in the gender categories.

Table 2 Epidemiologic description and treatment of missing teeth in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) by education group

Variable		35- to 44-year-olds			65- to 74-year-olds		
		Education group			Education group		
		Low	Medium	High	Low	Medium	High
No. of participants (n)		80	408	383	158	367	230
Full dentition (base 28 teeth, prevalence)		27.5%	51.3%	68.3%	3.9%	4.3%	13.4%
Edentulism (base 32 teeth, prevalence)	Maxilla only	0.7%	0.1%	0.0%	20.1%	11.0%	3.2%
	Mandible only	2.1%	0.0%	0.0%	12.8%	6.4%	3.3%
	Total	0.7%	0.0%	0.0%	8.8%	5.0%	1.9%
Number of missing teeth (base 28 teeth)	Total	3.3	1.5	0.8	11.4	9.1	5.7
	Not replaced	1.7	1.0	0.6	2.5	2.0	1.5
	Replaced by pontics	0.6	0.3	0.1	1.3	1.6	1.5
	Replaced by removable dentures	0.9	0.1	0.0	7.2	4.9	1.6
	Replaced by implants	0.1	0.2	0.1	0.5	0.6	1.0
Percentage of missing teeth that have been replaced (%)		36.4	29.4	24.1	65.8	65.2	59.7

Data are presented as unweighted numbers (n) and weighted percentages or weighted means.

edentulism was observed in 22.6% (DMS IV) and 12.4% (DMS V) of seniors, respectively. In this study, the prevalence of complete edentulism in the senior group was 5.0%, which indicates a reduction of > 50% (Table 1). Furthermore, the prevalence was approximately 3.0% greater in men than in women. In contrast, the prevalence of complete edentulism was insignificant in younger adults, and complete edentulism was not detected in participants with a medium or high education status. Additionally, the education status influenced the number of missing teeth in both age groups. Compared with the group with a high

Table 3 Primary prosthetic treatment in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) by gender

	Primary prosthetic treatment (prevalence)	35- to 44-year-olds			65- to 74-year-olds		
			Gender			Gender	
		Total	Male	Female	Total	Male	Female
No. of participants (n)		927	459	467	797	375	422
Total dentition	Fully dentate (no gaps, no dentures)	38.5%	40.6%	36.2%	1.1%	1.4%	0.7%
	≥ 1 untreated gap, no dentures	19.0%	21.2%	17.0%	4.4%	5.8%	3.0%
	≥ 1 crown restoration	25.9%	23.6%	28.3%	16.9%	20.3%	13.7%
	≥ 1 fixed denture (ie, bridge/implant)	15.1%	12.8%	17.3%	47.8%	43.4%	52.0%
	≥ 1 removable partial denture	1.3%	1.7%	1.0%	19.1%	17.7%	20.3%
	≥ 1 complete denture	0.2%	0.2%	0.3%	10.8%	11.4%	10.2%
Maxilla	Fully dentate (no gaps, no dentures)	50.9%	54.0%	47.6%	3.3%	4.9%	1.9%
	≥ 1 untreated gap, no dentures	16.6%	17.4%	15.9%	6.1%	7.6%	4.6%
	≥ 1 crown restoration	20.2%	16.8%	23.6%	25.5%	26.9%	24.2%
	≥ 1 fixed denture (ie, bridge/implant)	11.1%	10.1%	12.2%	38.8%	34.0%	43.3%
	≥ 1 removable partial denture	1.0%	1.5%	0.5%	16.6%	15.8%	17.3%
	≥ 1 complete denture	0.2%	0.2%	0.3%	9.8%	10.8%	8.8%
Mandible	Fully dentate (no gaps, no dentures)	54.3%	55.8%	52.7%	3.4%	3.3%	3.4%
	≥ 1 untreated gap, no dentures	17.7%	20.6%	15.1%	10.9%	13.1%	8.8%
	≥ 1 crown restoration	18.6%	15.9%	21.3%	22.8%	24.3%	21.3%
	≥ 1 fixed denture (ie, bridge/implant)	8.3%	6.3%	10.2%	40.5%	36.4%	44.4%
	≥ 1 removable partial denture	0.9%	1.2%	0.5%	18.0%	17.2%	18.7%
	≥ 1 complete denture	0.2%	0.1%	0.3%	4.5%	5.7%	3.4%

Data are presented as unweighted numbers (n) and weighted percentages. One gender-diverse individual is included in the total column, but not in the gender categories.

education status, in the group with a low education status, 2.5 more teeth were missing in younger adults, and in younger seniors twice as many teeth were missing (Table 2). In contrast, the remaining gender-related differences were small (Table 1).

The number of teeth replaced by pontics in the senior group was comparable to that in DMS V; however, the number of teeth replaced by removable dentures reduced by 50%. In contrast, the frequency of implant restorations increased by 2 to 3 times (younger adults, 0.06 to 0.1; younger seniors, 0.22 to 0.7). Nonetheless, the rate of replacement of missing teeth with implants was low. A comparison of the general trends in denture-related epidemiologic indicators is shown in Appendix 1.

Primary prosthetic treatment

Among younger adults, 38.5% had a full dentition, and only 16.6% were provided with dentures, with fixed and removable dentures accounting for 15.1% and 1.5% of participants, respectively. In contrast, only 1.1% of the younger seniors were fully edentate and 77.7% had dentures. Although the proportion of participants without any dental prostheses (not even a crown) remained almost unchanged compared to the results of DMS V (DMS V, 6.6%; DMS • 6, 5.5%), a considerable shift toward fixed partial dentures was observed (crowns [+5.9% points] and bridges [+11.2% points]). In contrast, the proportion of removable partial dentures (−8.9% points) and complete dentures (−7% points) decreased considerably. Overall, fixed dentures replaced removable dentures as the dominant treatment modality in this age group (Table 3). Men were more likely to be fully dentate than women and more likely to go without dentures in most of the subgroups analyzed. Full dentures were approximately twice as frequent in the maxilla than in the mandible (9.8% vs 4.5%), which is consistent with the findings of previous studies.[2,3]

Participants' education status was clearly related to the primary prosthetic treatment. In the high education group, 48.2% of younger adults were fully dentate and only 10.4% had

Table 4 Primary prosthetic treatment in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) by education group

Primary prosthetic treatment (prevalence)		35- to 44-year-olds			65- to 74-year-olds		
		Education group			Education group		
		Low	Medium	High	Low	Medium	High
No. of participants (n)		80	408	383	158	367	230
Total dentition	Fully dentate (no gaps, no dentures)	14.4%	35.6%	48.2%	1.6%	0.6%	1.7%
	≥ 1 untreated gap, no dentures	30.6%	18.3%	15.8%	3.8%	4.9%	1.3%
	≥ 1 crown restoration	21.6%	26.6%	25.6%	10.3%	13.5%	29.5%
	≥ 1 fixed denture (ie, bridge/implant)	27.2%	17.6%	10.4%	40.0%	49.3%	51.8%
	≥ 1 removable partial denture	4.0%	1.9%	0.1%	25.0%	20.0%	13.4%
	≥ 1 complete denture	2.1%	0.1%	0.0%	19.3%	11.8%	2.3%
Maxilla	Fully dentate (no gaps, no dentures)	28.7%	48.9%	59.4%	3.9%	2.6%	4.0%
	≥ 1 untreated gap, no dentures	21.4%	16.8%	14.2%	5.9%	7.3%	1.9%
	≥ 1 crown restoration	22.1%	18.4%	21.2%	15.5%	22.4%	38.8%
	≥ 1 fixed denture (ie, bridge/implant)	22.6%	14.4%	5.1%	35.3%	39.0%	42.2%
	≥ 1 removable partial denture	3.0%	1.4%	0.1%	22.3%	17.7%	11.1%
	≥ 1 complete denture	2.1%	0.1%	0.0%	17.2%	11.0%	1.9%
Mandible	Fully dentate (no gaps, no dentures)	33.2%	51.0%	63.3%	3.2%	2.2%	6.1%
	≥ 1 untreated gap, no dentures	33.0%	17.8%	11.8%	12.4%	12.3%	5.4%
	≥ 1 crown restoration	15.7%	21.0%	17.2%	20.2%	19.3%	32.8%
	≥ 1 fixed denture (ie, bridge/implant)	11.9%	9.2%	7.5%	30.1%	42.2%	45.4%
	≥ 1 removable partial denture	4.0%	1.0%	0.1%	26.9%	18.9%	9.2%
	≥ 1 complete denture	2.1%	0.0%	0.0%	7.2%	5.2%	1.1%

Data are presented as unweighted numbers (n) and weighted percentages.

bridges or implants. Removable dentures were almost absent in this group. In the senior group, participants with a low education status were five times more likely to be edentulous and fitted with a complete denture than those with a high education status. One third of the latter subgroup (32.5%) did not have any denture, whereas in the corresponding group with a low education status, removable dentures represented the main prosthetic restoration, at 44.3% (Table 4).

Prosthetic treatment

Fixed prostheses dominated in both age groups, and only 12 removable partial dentures were noted in the younger adults. Missing teeth were replaced only in 10.0% of the participants. In the senior group, 37.4% of participants had removable dentures (DMS V, 45.8%),[2] with combined fixed–removable dentures predominating.

Among younger adults, implant-supported restorations were exclusively found in combination with fixed dentures. The prevalence of participants with implants in this group doubled to 7.1% compared to 3.4% in DMS V,[3] although the number of implants per patient with implants remained almost unchanged at 1.7 (DMS V, 1.8). In the younger senior group, the prevalence of implants almost tripled compared to that in DMS V (23.2% vs 8.1%), although the mean number of implants per patient with implants increased only slightly (3.1 vs 2.7).[2] In this group too, implants were predominantly used to support fixed dentures (87.5%). Moreover, education status remained a determining factor (Table 5).

Removable denture quality and wearing behavior

No results are reported for younger adults owing to the small number of cases. Regarding denture quality among the younger seniors, only 50% to 60% of the removable dentures, including

Table 5 Prosthetic treatment in younger adults (35- to 44-year-olds) and younger seniors (65- to 74-year-olds) by gender and education group

Age group	Prosthetic treatment		Total	Gender		Education group		
				Male	Female	Low	Medium	High
35- to 44-year-olds	No. of participants (n)		927	459	467	80	408	383
	Fixed dentures (prevalence)	On natural teeth	39.7%	34.7%	44.7%	51.3%	42.9%	34.6%
		Partial crowns/inlays	9.6%	7.2%	11.9%	4.9%	9.7%	10.9%
		Full crowns	31.7%	27.2%	36.0%	42.0%	33.5%	27.3%
		Bridges	10.0%	8.9%	11.0%	24.2%	11.6%	5.9%
	Removable dentures (prevalence)	Due to the small number of cases, the values are provided in Appendix 1						
	Implants (prevalence)	Total	7.1%	6.0%	8.2%	5.7%	9.0%	5.3%
		With fixed dentures	7.1%	6.0%	8.2%	5.7%	9.0%	5.3%
		With removable dentures	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	No. of implants per patient with implants		1.7	1.7	1.7	1.7	2.0	1.4
65- to 74-year-olds	No. of participants (n)		797	375	422	158	367	230
	Fixed dentures (prevalence)	On natural teeth	79.7%	77.8%	81.5%	67.3%	78.5%	93.4%
		Partial crowns/inlays	24.2%	23.4%	24.9%	11.0%	22.1%	39.8%
		Full crowns	71.7%	68.0%	75.3%	60.5%	70.0%	85.6%
		Bridges	51.7%	44.1%	59.0%	47.1%	54.3%	50.8%
	Removable dentures (prevalence)	Total	19.6%	20.8%	18.4%	30.4%	20.9%	8.9%
		Acrylic partial denture	3.6%	2.7%	4.4%	4.5%	3.3%	3.2%
		Cast framework partial denture	7.7%	9.4%	6.1%	7.9%	9.9%	4.5%
		Combined fixed–removable partial denture	15.1%	13.5%	16.7%	23.4%	15.6%	7.7%
		Hybrid denture	0.2%	0.5%	0.0%	0.0%	0.0%	0.8%
		Complete denture	10.8%	11.4%	10.2%	19.3%	11.8%	2.3%
	Implants (prevalence)	Total	23.2%	22.7%	23.7%	18.6%	20.7%	30.3%
		With fixed dentures	20.3%	19.5%	21.0%	11.7%	18.9%	28.5%
		With removable dentures	2.9%	3.2%	2.7%	6.9%	1.8%	1.9%
	No. of implants per patient with implants		3.1	3.5	2.7	2.7	3.0	3.4

Data are presented as unweighted numbers (n) and weighted percentages or weighted means. One gender-diverse individual is included in the total column, but not in the gender categories.

combined fixed–removable partial dentures, were in a very good or good clinical condition, and the remaining required extensive repairs. Major deficiencies were found more frequently in acrylic-based dentures than in cast framework removable partial dentures or combined fixed–removable partial dentures. Interestingly, more than half of the non-framework acrylic partial dentures were fully functional, whereas approximately 40% of all other types of dentures showed no need for repair (Table 6).*

Simple acrylic-based removable dentures were worn sporadically or not at all in 14.8% of cases. In contrast, 95% of other removable dentures were worn continuously, with the combined fixed–removable partial dentures having the highest acceptance rate (97.3%).

*For reasons of clarity, the numbers, percentages, and means in the tables are presented without confidence intervals. Appendix 1 provides all values with the corresponding 95% confidence intervals.

Table 6 Removable denture quality and wearing behavior in younger seniors (65- to 74-year-olds)

Variable		Total	Acrylic partial denture	Cast framework partial denture	Combined fixed–removable partial denture*	Hybrid denture†	Complete denture
No. of dentures (n)		387	39	69	162	1	107
Removable denture quality (%)	No deficiencies, very good quality	41.4	51.6	40.1	40.3	100.0	39.7
	Acceptable condition, good quality	15.6	7.3	13.3	18.3	0.0	16.1
	Moderate deficiencies, moderate quality	26.8	5.9	34.6	29.8	0.0	24.5
	Major deficiencies, poor quality	16.2	35.2	12.0	11.6	0.0	19.7
Dentures: wearing behavior (%)	Dentures are worn	94.4	85.2	94.4	97.3	100.0	94.6
	Dentures are not worn or only worn sporadically	5.1	14.8	5.6	2.7	0.0	5.4

Data are presented as unweighted numbers (n) and weighted percentages, unit of analysis = dentures.
*Anchored via double crowns, precision attachments, or bars.
†Anchored only via root caps.

Discussion

Complete edentulism, as the final stage of caries and periodontal disease, has a considerable impact on nutritional behavior and quality of life. However, the changes can only be partially restored using complete dentures.[10] The most important finding in the present study is the continued significant decline in the prevalence of complete edentulism among seniors (prevalence, 5.0%), compared to that in previous studies (DMS III [1997], 24.8%; DMS IV [2005], 22.6%; DMS V [2014], 12.4%). The decrease in the number of missing teeth in younger adults compared to that in DMS V suggests a further reduction in edentulism in the future. Notably, the senior group in this study is comparable to the group of adults from DMS III with an average tooth loss (based on 28 teeth) of 4.2 teeth. Thus, the prevalence of edentulism in the entire resident population in Germany is supposed to reach 4.2% by 2030, as predicted by Schwendicke et al,[11] based on previous DMS data. However, this assumes that the general conditions for dental care in Germany remain at the present status quo, as socioeconomic factors significantly influence tooth loss and edentulism. Accordingly, the observed influence of the education status was to be expected.

The shift in primary prosthetic care from removable to fixed dentures is a positive development, because the chewing function and quality of life with fixed restorations are almost equivalent to those with natural teeth. The recent decades have seen a trend toward more frequent treatments with fixed partial dentures (bridges) and removable partial dentures, and complete dentures are used less frequently.[12-14] The increasing number of implants inserted will further support and accelerate this trend.

Despite the relatively high proportion of removable dentures that required repair (40.0%), most participants were satisfied with their dentures. Moreover, apart from simple acrylic partial dentures, which were often interim dentures, all other types of dentures were worn almost continuously. The fact that satisfaction with dentures does not correlate with the condition of the dentures ("paradox of old age," oral-geriatric paradox) has previously been described.[15,16]

Conclusion

The data clearly show further compression of morbidity. This is consistent with the trend observed in previous studies. Furthermore, the prevalence of complete edentulism continued to decrease considerably; however, education status was an important influencing factor. Patients are increasingly opting for fixed restorations with or without implant support. The use of removable dentures is decreasing. However, combined fixed–removable partial dentures were the predominant restoration in the senior group and were worn almost without exception.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. BW is a member of the scientific advisory board of the DMS • 6 and an author of the manuscript. StS is a member of the scientific advisory board of the DMS • 6, participated in drafting the SOP, trained the study dentists, and is an author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. IN is a member of the scientific advisory board of the DMS V and DMS • 6, was involved in creating the SOP, was co-responsible for developing the clinical examinations for dental prosthetics and senior dentistry, and is a co-author of the manuscript. HS is a member of the scientific advisory board of the DMS V and DMS • 6 and is a co-author of the manuscript.

Dedication

This work is dedicated to Professor Dr med dent Reinhard Marxkors (1932–2024), former Director of the Department of Prosthodontics of the Westfälische Wilhelms-Universität Münster, for his inspiring work in the field of prosthodontics.

References

1. GKV-Spitzenverband. GKV-Kennzahlen. Ausgaben für Zahnersatz 2019–2023; 2024. https://www.gkv-spitzenverband.de/gkv_spitzenverband/presse/zahlen_und_grafiken/gkv_kennzahlen/gkv_kennzahlen.jsp. Accessed 5 Sept 2024.

2. Nitschke I, Stark H. Krankheits- und Versorgungsprävalenzen bei Jüngeren Senioren (65- bis 74-Jährige). Zahnverlust und prothetische Versorgung. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016:416–451.

3. Stark H, Nitschke I. Krankheits- und Versorgungsprävalenzen bei Jüngeren Erwachsenen (35- bis 44-Jährige). Zahnverlust und prothetische Versorgung. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016:335–358.

4. Jordan AR, Hertrampf K, Hoffmann T, et al. Zahnmedizinische Erhebungskonzepte. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016: 85–116.

5. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

6. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

7. Marxkors R. Kriterien für die zahnärztliche Prothetik. Partielle Prothese. Studienhandbuch des Projektes: Qualitätssicherung in der Zahnmedizin. Würzburg, 1988.

8. Kerschbaum T. Zahnverlust und prothetische Versorgung. In: Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006:354–373.

9. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

10. Borg-Bartolo R, Roccuzzo A, Molinero-Mourelle P, et al et al. Global prevalence of edentulism and dental caries in middle-aged and elderly persons: a systematic review and meta-analysis. J Dent 2022;127:104335.

11. Schwendicke F, Nitschke I, Stark H, Micheelis W, Jordan RA. Epidemiological trends, predictive factors, and projection of tooth loss in Germany 1997–2030: part II. Edentulism in seniors. Clin Oral Investig 2020;24:3997–4003.

12. Zitzmann NU, Hagmann E, Weiger R. What is the prevalence of various types of prosthetic dental restorations in Europe? Clin Oral Implants Res 2007;18(Suppl 3): 20–33.

13. Zitzmann NU, Staehelin K, Walls AWG, Menghini G, Weiger R, Zemp Stutz E. Changes in oral health over a 10-yr period in Switzerland. Eur J Oral Sci 2008;116:52–59.

14. Mundt T, Schwahn C, Schmidt CO, Biffar R, Samietz S. Prosthetic tooth replacement in a German population over the course of 11 years: results of the study of health in Pomerania. Int J Prosthodont 2018;31:248–258.

15. Colussi CF, De Freitas SF, Calvo MC. The prosthetic need WHO index: a comparison between self-perception and professional assessment in an elderly population. Gerodontology 2009;26:187–192.

16. Nitschke H, Wefers K-P, Ludwig E. Definitionen. In: Nitschke I, Wefers K-P, Jockusch J (eds). Mobile Zahnmedizin. Die aufsuchende Betreuung. 1st edition. Berlin: Quintessenz, 2023:302.

Bernd Wöstmann **Stefanie Samietz**

Bernd Wöstmann* Director and Chair, Department of Prosthodontics, Justus-Liebig-University Giessen, Giessen, Germany

Stefanie Samietz* Senior Researcher, Clinician, Department of Prosthodontics, Gerodontology and Dental Materials, University Medicine Greifswald, Greifswald, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Ina Nitschke# Senior Physician, Gerodontology Section, Department of Prosthetic Dentistry and Materials Science, Leipzig University, Leipzig, Germany

Helmut Stark# Head, Zentrum für ZMK, Department of Prosthodontics, Preclinical Education and Dental Materials Science, University Hospital Bonn, Bonn, Germany

*#The authors contributed equally to this article.

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Appendix 1

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/tooth-loss-and-denture-status-results-of-the-6th-german-oral-health-study-dms-6-online-appendix/.

Molar incisor hypomineralization: results of the 6th German Oral Health Study (DMS • 6)

Katrin Bekes, Prof Dr med dent, MME/Hendrik Meyer-Lueckel, Prof Dr med dent, MPH/
A. Rainer Jordan, Prof Dr med dent, MSc/Kathrin Kuhr, Dr rer medic/Ulrich Schiffner, Prof Dr med dent

Objectives: The aim of this study was to determine the prevalence of molar incisor hypomineralization (MIH) in Germany. A secondary goal was to analyze a possible connection between MIH and caries, as well as to investigate the influence of MIH on oral health-related quality of life (OHRQoL). **Method and materials:** All younger adolescents (12-year-olds) from the 6th German Oral Health Study (DMS • 6) were examined for MIH according to the criteria of the European Academy of Paediatric Dentistry (EAPD). The caries experience and OHRQoL were also determined. **Results:** In total, 922 younger adolescents were included in the analysis. The prevalence of MIH was 15.3%; 63.3% of cases were mild forms; 8.2% of affected subjects had a caries experience. OHRQoL did not vary significantly between healthy and MIH-affected children. **Conclusion:** In Germany, every seventh 12-year-old suffers from MIH. These data on MIH in younger adolescents in Germany conform to data from regional studies; the prevalence is in the upper middle range in an international comparison. *(Quintessence Int 2025;56 (Suppl):S70–S74; doi: 10.3290/j.qi.b5986273)*

Keywords: dental care, dentists, DMS 6, epidemiology, molar hypomineralization, prevalence, quality of life

Molar incisor hypomineralization (MIH) is a developmental defect of the hard tissue of the tooth that results in reduced mineralization of the enamel. It usually occurs on one to all four first permanent molars; the permanent incisors may also be affected.[1] The condition is characterized by demarcated opacities, posteruptive enamel breakdowns, and sometimes the occurrence of hypersensitivity. The etiology has not been fully identified.[2]

MIH is prevalent globally. It is estimated to affect between 13% and 14% of children.[3-5] However, the frequency reported in the literature varies greatly.[6,7] For Germany, data are available from various regional studies as well as nationally from the Fifth German Oral Health Study (DMS V). There are regional variances in the prevalence from 4.3%[8] to 17.4%.[9] However, according to the latest DMS V, in 2014 almost 30% of 12-year-olds had MIH.[10]

The aim of the 6th German Oral Health Study (DMS • 6) was to determine the current prevalence of MIH among 12-year-olds. A second goal was to analyze the associations between MIH and the occurrence of caries, and the effect that hypomineralization can have on oral health-related quality of life (OHRQoL).

Method and materials

The general methodology of the study is presented in separate articles.[11,12] The DMS • 6 has been approved by the institutional review board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

In total, 36 younger adolescents from the DMS • 6 analysis set were excluded either because there were indications for a disease other than MIH (n = 4 children with suspected fluorosis) or because they were undergoing orthodontic treatment and the

Table 1 Epidemiologic description and care of molar incisor hypomineralization (MIH) by gender and education groups in younger adolescents (12-year-olds)

Variable		Total	Gender		Education group		
			Male	Female	Low	Medium	High
No. of participants (n)		922	469	453	83	404	370
MIH (prevalence)		15.3% (13.0; 17.6)	16.6% (13.6; 20.2)	13.7% (10.9; 17.3)	13.2% (7.1; 20.4)	12.2% (9.3; 15.8)	16.5% (12.9; 20.5)
Maximum degree of expression (%)	No MIH	84.7 (82.4; 87.0)	83.4 (79.8; 86.4)	86.3 (82.7; 89.1)	86.8 (78.4; 92.1)	87.8 (84.2; 90.7)	83.5 (79.2; 86.8)
	Demarcated opacity	9.7 (7.8; 11.6)	10.2 (7.6; 13.0)	9.1 (6.7; 12.0)	11.0 (5.5; 17.9)	7.2 (4.9; 10.0)	9.1 (6.5; 12.4)
	Posteruptive enamel breakdown, circumscribed	1.3 (0.7; 2.2)	1.4 (0.6; 2.8)	1.1 (0.4; 2.5)	1.3 (0.1; 4.8)	0.7 (0.2; 2.0)	2.1 (1.0; 4.0)
	Posteruptive enamel breakdown, extensive	0.1 (0.0; 0.5)	0.1 (0.0; 1.0)	0.1 (0.0; 1.1)	0.0 (NA)	0.0 (NA)	0.3 (0.0; 1.3)
	Atypical restoration	4.1 (3.0; 5.5)	4.6 (2.9; 6.7)	3.4 (2.0; 5.4)	0.9 (0.1; 4.8)	3.9 (2.3; 6.1)	5.0 (3.0; 7.4)
	Extraction due to MIH	0.1 (0.0; 0.5)	0.3 (0.0; 1.0)	0.0 (NA)	0.0 (NA)	0.3 (0.0; 1.2)	0.0 (NA)
Maximum degree of expression if ≥ 1 MIH tooth (%)	No MIH	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)
	Demarcated opacity	63.3 (55.0; 70.8)	61.0 (49.6; 70.6)	66.2 (53.1; 76.6)	83.5 (56.4; 96.4)	58.9 (44.2; 71.5)	55.2 (43.2; 67.7)
	Posteruptive enamel breakdown, circumscribed	8.4 (4.7; 14.0)	8.7 (3.9; 16.2)	8.0 (3.2; 17.0)	9.8 (0.9; 32.8)	5.9 (1.8; 15.7)	12.9 (6.4; 23.2)
	Posteruptive enamel breakdown, extensive	0.8 (0.1; 3.3)	0.8 (0.1; 5.6)	0.8 (0.2; 7.4)	0.0 (NA)	0.0 (NA)	1.9 (0.2; 7.4)
	Atypical restoration	26.6 (20.1; 34.7)	27.8 (18.4; 37.5)	24.9 (15.1; 36.4)	6.6 (0.9; 32.8)	32.4 (19.5; 45.2)	30.1 (19.2; 41.7)
	Extraction due to MIH	0.9 (0.1; 3.3)	1.7 (0.1; 5.6)	0.0 (NA)	0.0 (NA)	2.8 (0.2; 9.3)	0.0 (NA)
MIH teeth among all children		0.5 (0.5; 0.6)	0.6 (0.5; 0.8)	0.4 (0.3; 0.6)	0.4 (0.2; 0.7)	0.5 (0.3; 0.6)	0.6 (0.4; 0.7)
MIH teeth if ≥ 1 MIH tooth		3.4 (3.1; 3.7)	3.7 (3.2; 4.1)	3.1 (2.7; 3.5)	3.2 (2.1; 4.2)	3.5 (2.8; 4.2)	3.5 (3.0; 3.9)

Data are presented as unweighted numbers (n) and weighted percentages or weighted means (with 95% confidence intervals).
NA, not available.

Table 2 Epidemiologic description and care of molar incisor hypomineralization (MIH) by caries (experience) in younger adolescents (12-year-olds)

Variable		Tooth decay		Caries experience	
		DT = 0	DT > 0	DMFT = 0	DMFT > 0
No. of participants (n)		854	68	736	186
MIH (prevalence)		16.3%	3.9%	17.3%	8.2%
Maximum degree of expression (%)	No MIH	83.7	96.1	82.7	91.8
	Demarcated opacity	10.3	2.5	11.5	3.2
	Posteruptive enamel breakdown, circumscribed	1.4	0.0	1.4	0.9
	Posteruptive enamel breakdown, extensive	0.1	0.0	0.2	0.0
	Atypical restoration	4.3	1.4	4.2	3.7
	Extraction due to MIH	0.2	0.0	0.1	0.3

Data are presented as unweighted numbers (n) and weighted percentages. 95% confidence intervals are not given due to low cell counts.
DMFT, decayed, missing, filled teeth; DT, decayed teeth.

first molars were banded and could not be assessed (n = 32). A total of 922 younger adolescents were included in the analysis.

Measurement methods and variables

The MIH findings for the permanent central and lateral incisors and first molars were used for the analyses. To be considered a case of MIH, at least one first molar had to show hypomineralization.[1] MIH was recorded and diagnosed according to the European Academy of Paediatric Dentistry (EAPD) criteria[13]:

- Demarcated opacity: clearly defined area with an altered coloration (whitish, yellowish to brownish) of the enamel; regular surface and thickness of the enamel; opacities of < 1 mm not recorded
- Posteruptive enamel breakdown, circumscribed (< ⅓ of the tooth surface): circumscribed, limited substance defect of the enamel, extending to less than ⅓ of the entire tooth crown, which only occurred after tooth eruption; loss is often associated with a preexisting demarcated opacity

Table 3 Assessment of oral health-related quality of life by molar incisor hypomineralization (MIH) prevalence in younger adolescents (12-year-olds)

	MIH (prevalence)	
OHIP	Yes	No
OHIP 1 (chewing)	1.4 (1.2; 1.5)	1.4 (1.4; 1.5)
OHIP 2 (taste)	1.0 (1.0; 1.0)	1.1 (1.1; 1.1)
OHIP 3 (everyday)	1.0 (1.0; 1.1)	1.1 (1.1; 1.1)
OHIP 4 (pain)	1.4 (1.3; 1.6)	1.6 (1.5; 1.6)
OHIP 5 (appearance)	1.3 (1.2; 1.5)	1.4 (1.4; 1.5)
OHIP total score	6.2 (5.8; 6.5)	6.7 (6.5; 6.8)

Data are presented as weighted means (with 95% confidence intervals).
OHIP, Oral Health Impact Profile.

Table 4 Trends in epidemiology and care of molar incisor hypomineralization (MIH) in younger adolescents (12-year-olds) from DMS V to DMS • 6

Variable		DMS V	DMS • 6
No. of participants (n)		1,468	922
MIH (prevalence)		28.7%	15.3%
Maximum degree of expression (%)	No MIH	71.3	84.7
	Demarcated opacity	23.3	9.7
	Posteruptive enamel breakdown, circumscribed	2.8	1.3
	Posteruptive enamel breakdown, extensive	0.4	0.1
	Atypical restoration	2.1	4.1
	Extraction due to MIH	0.1	0.1
MIH teeth among all children		0.8	0.5
MIH teeth if ≥ 1 MIH tooth		2.7	3.4

Data are presented as unweighted numbers (n) and weighted percentages or weighted means.

- Posteruptive enamel breakdown, extensive (> ⅓ of the tooth surface): extensive substance defect, extending to more than ⅓ of the entire tooth crown
- Atypical restoration: The size and shape of the restoration do not correspond to the typical extent of the caries; atypical restoration often extends to the buccal and palatal/lingual surface in molars; opacity is often visible at the restoration margin; a buccal restoration that cannot be attributed to trauma is visible in incisors
- Extraction due to MIH: Absence of a first molar to be viewed in relation to the other teeth; indications include simultaneous demarcated opacities or atypical restorations on the other first molars, or the absence of a first molar in an otherwise intact dentition if demarcated opacities are present on the incisors
- Tooth not erupted: The first molar or incisors have not yet erupted.

In addition, the caries experience (decayed, missing, filled teeth [DMFT]) and the care status as well as the OHRQoL were recorded. The latter was measured using the short version of the Oral Health Impact Profile for schoolchildren (OHIP-5).[14,15]

Statistical analysis

A descriptive analysis of the prevalence, the distribution of the clinical severities and the treatment of MIH following caries (experience), as well as of the OHRQoL, was carried out. For the epidemiologic description, prevalences and averages with associated 95% confidence intervals (CIs) were calculated using a weighted dataset. The aim was to compensate for different probabilities in the selection of subjects and differences in gender, age, and region compared to the population in Germany by using the weighted dataset. Numbers (n) are provided without weighting. Detailed information on data handling and statistical methods is described previously.[16]

Results

The study included 922 younger adolescents (49% female). The prevalence of MIH was 15.3% (Table 1).

Younger adolescents with a higher family education status were more frequently affected. The majority of those with MIH (63.3%) showed demarcated opacities (and thus mild forms of MIH). Just under a tenth (9.2%) had untreated enamel breakdowns. Of the younger adolescents with MIH, 26.6% had already undergone restoration. Only in rare cases (0.9 %) had the MIH-affected teeth already been extracted. On average, 3.4 teeth were affected in younger adolescents with MIH.

With regard to caries experience, 8.2% (n = 20) of younger adolescents with MIH also showed caries experience (DMFT > 0). Only four of them (3.9%) also had decayed teeth (DT > 0) (Table 2).

The measurement of the OHRQoL showed no relevant differences between younger adolescents with and without MIH, both in the total score (6.2 vs 6.7) and in the five dimensions (Table 3).

Discussion

The DMS • 6 shows that 15.3% of 12-year-olds in Germany have at least one first molar with hypomineralization. MIH findings are therefore no longer as prevalent as in the last DMS V. In the

latter, MIH was diagnosed in 28.7% of cases (Table 4).[10] The recent data thus correspond better to the regional prevalences found in Germany at different points in time than the last DMS. In a four-city study, Petrou et al[8] found an average prevalence of 10.1% (range 4.3% to 14.6%). In Munich, 14.7% were affected by MIH,[17] while in Frankfurt and its surroundings the prevalence was calculated as 13.1% (range 9.4% to 17.4%).[9] With around 15%, the current figures for 12-year-olds lie in the upper range of the regional figures; internationally, the percentage is in the middle range. Globally, the figures vary greatly, but the mean is estimated at 13% to 14%,[3-5] which corresponds approximately to the new data for Germany. It should, however, be noted that the German data may be higher and may even reach the 20% mark as orthodontic cases were excluded because the first molars could not be evaluated.

The assessment of the severity of MIH shows that in most of the younger adolescents with MIH the maximum severity is a demarcated opacity (63.3%). This finding is also in line with the regional studies carried out in Germany and with the international literature. Both, in the four-city study,[8] in Munich[17] and in the Frankfurt area,[9] demarcated opacities dominated – albeit in higher percentages of up to over 90%. However, these studies in part looked at younger children (from age 6). In the 12-year-olds, the first molars and incisors have erupted several years previously and have thus been subjected to (chewing) forces. There is therefore more time for the opacity to develop a possible posteruptive breakdown or to require restoration.

With regard to caries experience, it could be shown that 8.2% of younger adolescents with MIH had caries experience. Fortunately, untreated carious teeth were only found in four younger adolescents (DT > 0). This is also consistent with the literature, which states that younger adolescents with MIH have up to a 4.6-fold higher risk of caries.[18]

The measurement of OHRQoL did not find systematic differences between MIH-affected and healthy younger adolescents. There is currently no consensus in the literature as to whether MIH has a negative impact on a person's OHRQoL. Studies both in Germany as well as internationally have confirmed a lower OHRQoL with MIH,[19-21] but other international studies have not found this to be true.[22,23]

Conclusion

More than one adolescent in seven in Germany aged 12 years is affected by MIH. This confirms regional observations of the existence of an MIH problem epidemiologically. This high prevalence shows the need for further research on the causes and on ways to prevent the disease.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. KB is a member of the scientific advisory board of DMS • 6, responsible for the development of the clinical examinations, and is the author of the manuscript. HML and US are members of the scientific advisory board of the DMS • 6 and responsible for the development of the clinical examinations. ARJ is the principal investigator of DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of DMS • 6, responsible for the data analysis, and a co-author of the manuscript.

References

1. Weerheijm KL, Jälevik B, Alaluusua S. Molar-incisor hypomineralisation. Caries Res 2001;35:390–391.
2. Garot E, Rouas P, Somani C, Taylor GD, Wong F, Lygidakis NA. An update of the aetiological factors involved in molar incisor hypomineralisation (MIH): a systematic review and meta-analysis. Eur Arch Paediatr Dent 2022;23:23–38.
3. Schwendicke F, Elhennawy K, Reda S, Bekes K, Manton DJ, Krois J. Global burden of molar incisor hypomineralization. J Dent 2018;68:10–18.

4. Schwendicke F, Elhennawy K, Reda S, Bekes K, Manton DJ, Krois J. Corrigendum to "Global burden of molar incisor hypomineralization", J Dent 2018;68C:10–18. J Dent 2019;80:89–92.

5. Zhao D, Dong B, Yu D, Ren Q, Sun Y. The prevalence of molar incisor hypomineralization: evidence from 70 studies. Int J Paediatr Dent 2018;28:170–179.

6. Soviero V, Haubek D, Trindade C, Da Matta T, Poulsen S. Prevalence and distribution of demarcated opacities and their sequelae in permanent 1st molars and incisors in 7 to 13-year-old Brazilian children. Acta Odontol Scand 2009;67:170–175.

7. Subramaniam P, Gupta T, Sharma A. Prevalence of molar incisor hypomineralization in 7–9-year-old children of Bengaluru City, India. Contemp Clin Dent 2016;7:11–15.

8. Petrou MA, Giraki M, Bissar A-R, et al. Prevalence of Molar-Incisor-Hypomineralisation among school children in four German cities. Int J Paediatr Dent 2014;24:434–440.

9. Amend S, Nossol C, Bausback-Schomakers S, et al. Prevalence of molar-incisor-hypomineralisation (MIH) among 6-12-year-old children in Central Hesse (Germany). Clin Oral Invest 2021;25:2093–2100.

10. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

11. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl):S4–S12.

12. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl): S14–S21.

13. Weerheijm KL, Duggal M, Mejàre IA, et al. Judgement criteria for molar incisor hypomineralization (MIH) in epidemiologic studies: a summary of the European meeting on MIH held in Athens, 2003. Eur J Paediatr Dent 2003;4:110–113.

14. John MT, Miglioretti DL, LeResche L, Koepsell TD, Hujoel P, Micheelis W. German short forms of the Oral Health Impact Profile. Community Dent Oral Epidemiol 2006;34:277–288.

15. Solanke C, John MT, Ebel M, Altner S, Bekes K. OHIP-5 for school-aged children. J Evid Based Dent Pract 2024;24(1S):101947.

16. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

17. Kühnisch J, Heitmüller D, Thiering E, et al. Proportion and extent of manifestation of molar-incisor-hypomineralizations according to different phenotypes. J Public Health Dent 2014;74:42–49.

18. Americano GCA, Jacobsen PE, Soviero VM, Haubek D. A systematic review on the association between molar incisor hypomineralization and dental caries. Int J Paediatr Dent 2017;27:11–21.

19. Joshi T, Rahman A, Rienhoff S, Rienhoff J, Stamm T, Bekes K. Impact of molar incisor hypomineralization on oral health-related quality of life in 8–10-year-old children. Clin Oral Invest 2022;26:1753–1759.

20. Reissenberger T, Ebel M, Klode C, Hirsch C, Bekes K. Hypomineralized teeth and their impact on oral-health-related quality of life in primary school children. Int J Environ Res Public Health 2022;19:10409.

21. Dantas-Neta NB, Moura LdFAdD, Cruz PF, et al. Impact of molar-incisor hypomineralization on oral health-related quality of life in schoolchildren. Braz Oral Res 2016;30:e117.

22. Dias FMCS, Gradella CMF, Ferreira MC, Oliveira LB. Molar-incisor hypomineralization: parent's and children's impact perceptions on the oral health-related quality of life. Eur Arch Paediatr Dent 2021;22:273–282.

23. Folayan MO, Chukwumah NM, Popoola BO, et al. Developmental defects of the enamel and its impact on the oral health quality of life of children resident in Southwest Nigeria. BMC Oral Health 2018;18:160.

Katrin Bekes

Katrin Bekes Head, Department of Paediatric Dentistry, University Clinic of Dentistry, Medical University of Vienna, Vienna, Austria

Hendrik Meyer-Lueckel Head, Department for Operative, Preventive and Pediatric Dentistry Executive Director of the zmk bern (Dental School of Bern), Bern, Switzerland

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Ulrich Schiffner Professor, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Erosions in younger adults in Germany: results of the 6th German Oral Health Study (DMS • 6)

Ulrich Schiffner, Prof Dr med dent/A. Rainer Jordan, Prof Dr med dent, MSc/Hendrik Meyer-Lueckel, Prof Dr med dent, MPH/Kathrin Kuhr, Dr rer medic/Katrin Bekes, Prof Dr med dent, MME

Objectives: In addition to caries, other dental hard tissue diseases, such as erosive wear, are gaining importance in prevention and treatment. The survey aimed to collect current data on the prevalence of erosions in younger adults and to compare these with the previous state of knowledge. **Method and materials:** As part of the representative 6th German Oral Health Study (DMS • 6), all teeth were assessed according to the basic erosive wear examination (BEWE). The maximum value of the findings per sextant was included in the evaluation. **Results:** The prevalence of erosions was found to be 43.2%. At 49.1%, men had significantly more erosions than women (37.8%). Younger adults with a high education status were affected by erosions more frequently than persons with a medium or low education status (49.2%, 37.9%, and 45.1%, respectively). **Conclusion:** The prevalence of erosions remains practically unchanged from the Fifth German Oral Health Study (DMS V) of 2014. However, the proportion of people at increased risk has risen sharply. The continued high prevalence of erosions combined with the increased proportion of people with a medium or high risk classification indicates that the prevention and treatment of erosive wear is a clinically relevant issue. *(Quintessence Int 2025;56(Suppl): S76–S81; doi: 10.3290/j.qi.b5982008)*

Keywords: dental care, dentists, DMS 6, educational status, epidemiology, prevalence, risk assessment, tooth erosion

The success of oral prevention in Germany is also reflected in younger adults, with a decline in their caries experience and, in particular, with a higher number of caries-free teeth.[1] However, this increases the likelihood of the teeth suffering from non-carious changes. This includes development-related tooth anomalies, but also various forms of tooth defects acquired over time, such as erosions. Dental erosion is defined as the loss of dental hard tissue due to the direct effect of acids without bacterial involvement.[2,3] The defects initially form in the enamel and then progress into the dentin. The source of the acids is mostly food and drink. Gastric acid is another factor that can result in large erosive losses in the tooth structure.[2,3] Details on the etiology of erosive wear can be found in reviews.[3,4]

Abrasions have a different etiology. As a result of mechanical influences such as habitually brushing the teeth too vigorously, they can occur as wedge-shaped defects in the cervical tooth region.[2] Hard tooth tissues that have been softened by erosion are lost more quickly to abrasion. This results in defects whose etiology is based both on acid action and on mechanical effects.[5] In their pure form, erosions have a trough-like shape with rounded curvatures at the transition of the defect to the surrounding tooth tissue.[6] Abrasions from brushing, in contrast, are marked by sharp angles at the transition to neighboring, unaffected tooth surfaces and at the base of the lesion. In everyday clinical practice, however, the shape of the defect often does not allow clear conclusions as to its erosive or mechanical origin.

The prevalence of erosions in younger adults globally is stated to vary widely from 4% to 100%.[7] The previous German Oral Health Studies (DMS) provide nationally representative data for Germany. For the DMS V in 2014, a prevalence of 44.8% was determined for 35- to 44-year-olds, while the DMS III in 1997 stated a lower prevalence of 27.2%.[8,9]

The present analysis intended, based on the epidemiologic findings of the 6th German Oral Health Study (DMS • 6), to update the figure for the prevalence of erosions in younger adults, to analyze the severity of the defects, and to compare the findings with previous investigations.

Method and materials

The general methodology of the study is presented in separate articles.[10,11] The DMS • 6 has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

A total of 924 adults were included in the analysis. In four younger adults from the DMS • 6 analysis set, the presence of erosions could not be recorded because they were either edentulous (n = 1) or had no tooth surfaces without clinical findings such as caries or restorations. Therefore, no tooth surface was available for diagnosis (n = 3).

Measurement methods and variables

Erosions were recorded using simple recording in accordance with the basic erosive wear examination (BEWE).[12] All teeth without a clinical finding, as well as teeth with fillings or partial crowns/inlays, were assessed for erosion in a separate recording sequence. The index differentiates between initial loss of surface structure (score 1) and clinically manifest erosions of less or more than 50% of the most affected tooth surface (scores 2 and 3). The extension of the defect into the dentin generally found in scores 2 and 3 was not specified as a gradation criterion.

For the survey, the main symptom used to determine more advanced erosive hard dental tissue loss was defined as a trough-shaped clinical appearance with rounded curvatures. If the erosive defects in part showed sharp ridges at their edges or bottom, which indicate the superposition of erosive and mechanical effects, these mixed forms of erosion and other defects were also recorded and registered in accordance with the BEWE. Exclusively wedge-shaped defects, in contrast, were not recorded.

The erosions were assessed tooth by tooth, with the most severe finding per sextant being recorded. In line with the BEWE, a risk classification was derived from the sum of the values for all sextants:

- score sum 0 to 2: no increased risk level
- score sum 3 to 8: slightly increased risk level
- score sum 9 to 13: medium risk level
- score sum 14 to 18: high risk level.

Statistical analysis

A descriptive analysis of the prevalence, a risk level classification (BEWE), and an analysis of the distribution of the BEWE maximum scores were carried out. For the epidemiologic description, prevalences with associated 95% confidence intervals (CIs) were calculated using a weighted dataset. The aim of using the weighted dataset was to compensate for different probabilities in the sampling of subjects and differences in sex, age, and region compared to the population in Germany. Numbers (n) are provided without weighting. Detailed information on data handling and statistical methods is described previously.[13]

Results

Information on erosion was available for 924 younger adults; 43.2% of these had at least one tooth with erosion (Table 1). There was a noticeable difference in prevalence between men and women, at 49.1% vs 37.8%. The prevalence also varied amongst younger adults based on their education status. While 37.9% of individuals with a medium education status had erosions, the proportions amongst younger adults with a low education status (45.1%) and a high education status (49.2%) were distinctly higher. The same differences were found with regard to the maximum score of the erosions. Here, too, women and people with a medium education status had considerably fewer erosions than men and subjects with a low or high education status (Table 1). Despite these differences, no social gradient could be identified for the formation of erosions in younger adults in Germany.

The addition of the maximum BEWE scores of the single sextants (Fig 1) resulted in a stratification of the erosion findings and the derived erosion risks (Table 2). This stratification showed a medium risk level in 12.6% of participants (BEWE score 9 to 13) and a high risk level in 2.9% (BEWE score 14 to 18). Again, female participants and people with a medium education status had markedly lower risk profiles (Table 2).

Discussion

The survey found that 43.2% of 35- to 44-year-olds in Germany have at least one tooth displaying erosive wear. This means that almost every second adult in this age group is affected by erosion. Table 3 juxtaposes the current data with the findings of the DMS III (1997) and DMS V (2014) in order to compare the prevalences and assess the statistical development nationally over time.[8,9] It can be seen that the prevalence of erosions is

Table 1 Epidemiologic description of erosions (BEWE) in younger adults (35- to 44-year-olds) overall, and by gender and education groups

Variable		Total	Gender		Education group		
			Male	Female	Low	Medium	High
No. of participants (n)		924	458	465	78	407	383
Erosions (prevalence)		43.2% (40.1; 46.5)	49.1% (44.5; 53.7)	37.8% (33.6; 42.3)	45.1% (34.2; 55.3)	37.9% (33.2; 42.7)	49.2% (44.1; 54.1)
Maximum BEWE score (%)	No erosion	56.8 (53.6; 60.0)	50.9 (46.3; 55.5)	62.2 (57.7; 66.4)	54.9 (43.5; 64.6)	62.1 (57.3; 66.8)	50.8 (45.6; 55.7)
	Initial loss of surface structures	11.9 (10.0; 14.1)	11.3 (8.7; 14.5)	12.6 (9.8; 15.8)	7.7 (3.1; 14.3)	11.7 (8.7; 14.9)	13.1 (10.1; 16.9)
	Clinically manifest defect; loss of tissue < 50% of the most severely affected tooth surface	26.2 (23.4; 29.0)	29.3 (25.3; 33.7)	23.4 (19.7; 27.4)	29.3 (20.0; 39.3)	22.6 (18.7; 26.8)	29.7 (25.1; 34.3)
	Clinically manifest defect; loss of tissue ≥ 50% of the most severely affected tooth surface	5.1 (3.8; 6.7)	8.5 (6.1; 11.3)	1.9 (1.0; 3.5)	8.1 (3.9; 15.8)	3.6 (2.2; 6.0)	6.5 (4.4; 9.4)
Maximum BEWE score if erosion present (%)	No erosion	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)
	Initial loss of surface structures	27.6 (23.4; 32.1)	23.1 (17.9; 29.0)	33.2 (26.5; 40.3)	17.2 (7.1; 30.4)	30.8 (23.5; 38.1)	26.6 (20.9; 33.6)
	Clinically manifest defect; loss of tissue < 50% of the most severely affected tooth surface	60.6 (55.5; 65.1)	59.6 (53.2; 66.0)	61.8 (54.5; 68.7)	65.0 (48.8; 78.7)	59.6 (51.7; 67.2)	60.2 (53.1; 67.0)
	Clinically manifest defect; loss of tissue ≥ 50% of the most severely affected tooth surface	11.8 (8.9; 15.2)	17.3 (12.7; 22.6)	5.0 (2.5; 9.0)	17.9 (8.9; 33.6)	9.6 (5.9; 15.5)	13.2 (9.1; 18.9)

Data are presented as unweighted numbers (n) and weighted percentages (with 95% confidence intervals) for dentate participants with valid information on erosion. One gender-diverse individual is included in the total column and the education groups, but not in the gender categories.
BEWE, basic erosive wear examination; NA, not available.

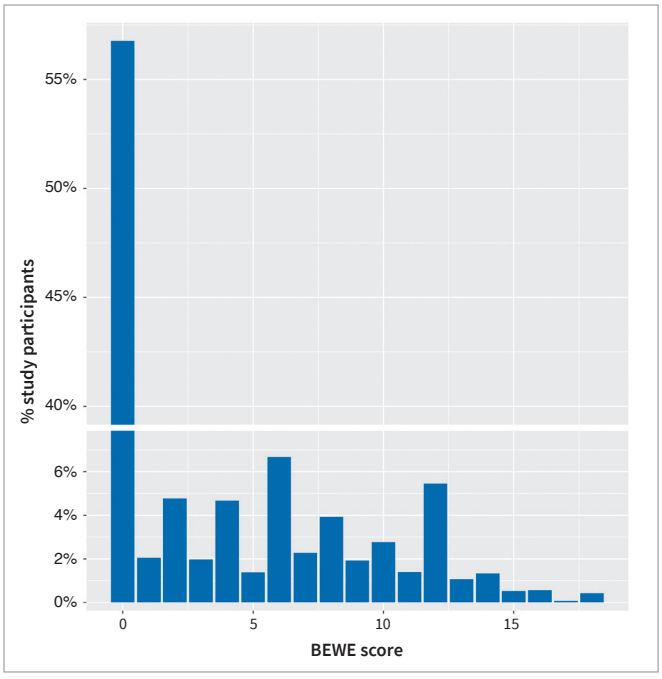

Fig 1 Distribution of the BEWE score sum of the maximum values for all sextants in younger adults (35- to 44-year-olds).

practically unchanged compared to the 2014 survey. Over a longer period, there was an increase in the prevalence of erosion compared to the 1997 survey; however, it should be noted that in the 1997 DMS III a different methodology was used, excluding occlusal erosions from the findings.

One figure that stands out is the much higher prevalence of erosions in men than in women. This finding conforms to the results of the previous national surveys.[8,9] However, the difference in prevalence of 11.3 percentage points in the current survey (49.1% in men, 37.8% in women) is around twice as high as in the previous surveys (1997: 5.9%[8]; 2014: 4.6%[9]). This higher prevalence of erosions in men compared to women is also found in the international literature,[7,14-16] sometimes to the same extent as identified in the present report.[17] Causes for the differences may be related to different eating behaviors,[16] reflux diseases,[16,17] or even the number of maintained teeth.[8]

The survey found different erosion prevalences according to education status, ranging from 37.9% in persons with a medium education status to 49.2% in study participants with a high education status. However, no linear correlation between higher

Table 2 Risk level classification of erosions (BEWE) in younger adults (35- to 44-year-olds) overall, and by gender and education groups

Variable		Total	Gender		Education group		
			Male	Female	Low	Medium	High
No. of participants (n)		924	458	465	78	407	383
Risk level classification (%)	No increased risk level	63.6 (60.4; 66.6)	56.5 (51.8; 61.0)	70.2 (66.0; 74.2)	57.2 (45.9; 66.9)	70.0 (65.3; 74.3)	58.1 (53.0; 62.9)
	Slightly increased risk level	20.9 (18.4; 23.6)	21.5 (17.9; 25.5)	20.4 (17.0; 24.2)	19.1 (11.9; 28.7)	18.7 (15.0; 22.6)	22.8 (18.7; 27.1)
	Medium risk level	12.6 (10.6; 14.8)	16.7 (13.4; 20.3)	8.7 (6.4; 11.5)	19.3 (11.9; 28.7)	9.9 (7.2; 13.0)	14.8 (11.5; 18.6)
	High risk level	2.9 (2.0; 4.2)	5.2 (3.5; 7.7)	0.7 (0.2; 1.7)	4.4 (1.6; 11.1)	1.4 (0.6; 3.1)	4.3 (2.5; 6.6)

Data are presented as unweighted numbers (n) and weighted percentages (with 95% confidence intervals) for dentate participants with valid information on erosion. One gender-diverse individual is included in the total column and the education groups, but not in the gender categories.
BEWE, basic erosive wear examination.

Table 3 Trends in prevalence, maximum score, and risk level classification of erosions (BEWE) in younger adults (35- to 44-year-olds) from DMS III, DMS V, and DMS • 6

Variable		DMS III* (1997)	DMS V (2014)	DMS • 6 (2023)
No. of participants (n)		655	961	924
Erosions (prevalence)		27.2%	44.8%	43.2%
Maximum BEWE score (%)	No erosion	72.8	55.2	56.8
	Low	6.4	15.5	11.9
	Medium	20.8†	27.4	26.2
	High		1.9	5.1
Risk classification (%)	No increased risk level	NA‡	70.4	63.6
	Slightly increased risk level		24.5	20.9
	Medium risk level		5.0	12.6
	High risk level		0.1	2.9

Data are presented as unweighted numbers (n) and weighted percentages for dentate participants with valid information on erosion.
*Without occlusal erosions.
†Classification different from BEWE.
‡The BEWE index used for the classification into risk levels was only developed in 2008.
BEWE, basic erosive wear examination; NA, not available.

education status and higher prevalence of erosion crystallized. A correlation between the prevalence of erosion and education group was found in a dataset of adults from seven European countries.[14] At the same time, a current review failed to identify a definite association with socioeconomic parameters.[16]

The comparison of the maximum erosion scores as well as the BEWE risk level classifications in the DMS V and the current data yields a significant finding (Table 3). The two surveys were carried out using the same methodology. While in the DMS V in 2014 a high maximum score was only found in 1.9% of participants,[9] the present figure is 5.1%. The shifts in the BEWE risk levels are even more striking. While in 2014, 5.0% of study participants were classified as having a medium risk level of erosion and only 0.1% as having a high risk level, in 2023, these figures were 12.6% and 2.9%, respectively. The proportion of younger adults in Germany with a medium or high prevalence of erosion has, therefore, tripled in 9 years. This finding is of clinical relevance with regard to the prevention and treatment of erosive wear.

Conclusion

The representative study found a high prevalence of erosive wear in younger adults in Germany. Almost every second per-

son in this group has at least one tooth affected by erosion. The prevalence is especially high amongst men. While the prevalence is practically unchanged compared to the 2014 survey using the same methodology, the proportions of younger adults with a high maximum degree of severity and with medium or high risk classification have tripled. These figures suggest that the prevention and treatment of erosive wear should receive more attention in dental medicine.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. US is a member of the scientific advisory board of the DMS • 6, responsible for developing the clinical examinations, and the author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. HML is a member of the scientific advisory board of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. KB is a member of the scientific advisory board of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript.

References

1. Jordan AR, Meyer-Lückel H, Kuhr K, Sasunna D, Bekes K, Schiffner U. Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S30–S39.

2. Ganss C. Is erosive tooth wear an oral disease? In: Lussi A, Ganss C (eds). Erosive tooth wear: From diagnosis to therapy. Monographs in Oral Science vol. 25. Basel: Karger, 2014:16–21.

3. Kanzow P, Wegehaupt FJ, Attin T, Wiegand A. Etiology and pathogenesis of dental erosion. Quintessence Int 2016;47: 275–278.

4. Carvalho TS, Colon P, Ganss C, et al. Consensus report of the European Federation of Conservative Dentistry: erosive tooth wear—diagnosis and management. Clin Oral Investig 2015;19:1557–1561.

5. Shellis RP, Addy M. The interactions between attrition, abrasion and erosion in tooth wear. In: Lussi A, Ganss C (eds). Erosive tooth wear: From diagnosis to therapy. Monographs in Oral Science vol. 25. Basel: Karger, 2014:32–45.

6. Lussi A, Jaeggi T. Erosion: diagnosis and risk factors. Clin Oral Investig 2008; 12(Suppl 1):S5–S13.

7. Jaeggi T, Lussi A. Prevalence, incidence and distribution of erosion. In: Lussi A, Ganss C (eds). Erosive tooth wear: From diagnosis to therapy. Monographs in Oral Science vol. 25. Basel: Karger, 2014:55–73.

8. Schiffner U, Micheelis W, Reich E. Erosionen und keilförmige Zahnhalsdefekte bei deutschen Erwachsenen und Senioren. Dtsch Zahnärztl Z 2002;57:102–106.

9. Schiffner U. Krankheits- und Versorgungsprävalenzen bei Jüngeren Erwachsenen (35- bis 44-Jährige). Karies und Erosionen. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016: 282–311.

10. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

11. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

12. Bartlett D, Ganss C, Lussi A. Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. Clin Oral Investig 2008;12(Suppl 1):S65–S68.

13. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

14. Bartlett DW, Lussi A, West NX, Bouchard P, Sanz M, Bourgeois DM. Prevalence of tooth wear on buccal and lingual surfaces and possible risk factors in young European adults. J Dent 2013;41:1007–1013.

15. Strużycka I, Lussi A, Bogusławska-Kapała A, Rusyan E. Prevalence of erosive lesions with respect to risk factors in a young adult population in Poland: a cross-sectional study. Clin Oral Invest 2017;21:2197–2203.

16. Marschner F, Kanzow P, Wiegand A. Anamnestic risk factors for erosive tooth wear: Systematic review, mapping, and meta-analysis. J Dent 2024;144:104962.

17. Stangvaltaite-Mouhat L, Pūrienė A, Stankeviciene I, Aleksejūnienė J. Erosive tooth wear among adults in Lithuania: A cross-sectional national oral health study. Caries Res 2020;54:283–291.

Ulrich Schiffner

Ulrich Schiffner Professor, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Hendrik Meyer-Lueckel Head, Department for Operative, Preventive and Pediatric Dentistry, Executive Director of the zmk bern (Dental School of Bern), University of Bern, Bern, Switzerland

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Katrin Bekes Head, Department of Paediatric Dentistry, University Clinic of Dentistry, Medical University of Vienna, Vienna, Austria

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Oral hygiene behavior and toothbrushing skills: results of the 6th German Oral Health Study (DMS • 6)

Renate Deinzer, Prof Dr rer nat/A. Rainer Jordan, Prof Dr med dent, MSc/Kathrin Kuhr, Dr rer medic/
Jutta Margraf-Stiksrud, Dr phil

Objectives: Past German Oral Health Studies (DMS) have revealed that toothbrushing patterns – a behavioral index comprising toothbrushing frequency, duration and timing – have steadily improved over the previous decades. What has not yet been investigated, however, are toothbrushing skills, ie, the ability to achieve oral cleanliness by removing all plaque deposits. **Method and materials:** All participants of the DMS • 6 from the age groups of 12-year-olds, 35- to 44-year-olds, and 65- to 74-year-olds were asked to brush their teeth to the best of their ability. To do so, they used their own devices or those provided. The plaque that remained after brushing was recorded using the modified Marginal Plaque Index (mMPI), expressing the percentage of segments remaining at the gingival margin that were colonized by plaque. Relationships to questionnaire data regarding demographics (age, gender, education status), toothbrushing behavior (frequency, utilization of an electric toothbrush), and selected dental treatments (professional tooth cleaning, lifetime periodontal treatment) were assessed. **Results:** Even following the best possible brushing, roughly half of the segments (44% to 52%) across all age groups showed persisting plaque deposits. Survey data revealed the most pronounced group differences regarding education, whereby even in the group of younger seniors with a high education status, 37% of the areas showed persisting plaque after cleaning. **Conclusion:** The data demonstrate that there are population-wide deficits in the ability to achieve oral cleanliness. Future prevention efforts should also focus on improving the population's toothbrushing skills. *(Quintessence Int 2025;56(Suppl):S82–S87; doi: 10.3290/j.qi.b5982011)*

Keywords: awareness, dental care, dental examinations, dentists, DMS 6, health behavior, oral hygiene, surveys and questionnaires, toothbrushing

Oral hygiene at home plays a central role in the prevention of tooth decay and periodontal disease. The majority of the population not only seems to be aware of this, but also puts it into practice in their behavior. The Fifth German Oral Health Study (DMS V)[1] found that more than 75% of older seniors (75- to 100-year-olds) and over 80% of other age groups stated that they brush their teeth at least twice a day, and less than 5% of all age groups reported brushing less than once a day.[2] The DMS V also notes that the toothbrushing pattern (a behavioral index of self-reported toothbrushing times, frequency and duration) has seen an improvement since the DMS III in 1997.[3] Nevertheless, the prevalence of diseases associated with poor oral hygiene at home is high. More than 60% of the younger adults and seniors analyzed in the DMS V had at least moderate periodontitis, while only 22% of the younger adolescents analyzed were free of gingivitis. These values are indicative of inadequate oral hygiene at home.

While survey data reveal that the majority of the population is sufficiently motivated to practice regular oral hygiene at home, clinical data indicate a lack in effectiveness. The reason behind this could be deficient brushing skills, ie, a limited ability to achieve the intended oral cleanliness by toothbrushing. National or international representative data on this subject are still lacking. The 6th German Oral Health Study (DMS • 6) has therefore made toothbrushing skills one of its research questions. The main findings are reported below.

Table 1 Baseline characteristics of study participants in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds)

Variable		12-year-olds	35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)		948	910	737
Age, years		12.7 ± 0.5	40.1 ± 2.9	69.7 ± 2.8
Gender	Male	478 (50.4%)	454 (49.9%)	344 (46.7%)
	Female	469 (49.5 %)	455 (50.0 %)	393 (53.3 %)
	Diverse	1 (0.1%)	1 (0.1%)	0 (0.0 %)
Education group	Low	82 (9.4 %)	78 (9.1%)	137 (19.6%)
	Medium	418 (47.7%)	400 (46.8%)	343 (49.1%)
	High	377 (43.0%)	377 (44.1%)	219 (31.3%)
Tooth brushing (frequency)	≥ 2 times daily	791 (84.6%)	744 (82.2%)	603 (84.0%)
	Once daily	122 (13.0%)	136 (15.0%)	91 (12.7%)
	< once daily	22 (2.4%)	25 (2.8%)	24 (3.3%)
Type of toothbrush used	Electric	302 (32.3%)	419 (46.3%)	300 (41.8%)
	Manual	488 (52.2%)	386 (42.7%)	334 (46.5%)
	Both	131 (14.0%)	82 (9.1%)	66 (9.2%)
	None	14 (1.5%)	18 (2.0%)	18 (2.0%)
Professional tooth cleaning (utilization)	Yes	NA	706 (78.6%)	592 (81.1%)
	No	NA	190 (21.2%)	135 (18.5%)
	Don't know	NA	2 (0.2%)	3 (0.4%)
Lifetime periodontal treatment (utilization)	Yes	NA	113 (12.6%)	236 (32.3%)
	No	NA	762 (84.8%)	468 (64.0%)
	Don't know	NA	24 (2.7%)	27 (3.7%)

Data are presented as numbers (percentages) or mean ± standard deviation based on unweighted data for dentate participants with valid plaque findings.
NA, not available.

Method and materials

The general methodology of the study is presented in separate articles.[4,5] The DMS • 6 was approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

The following analysis pertains to the age groups of younger adolescents (12-year-olds, n = 948), younger adults (35- to 44-year-olds, n = 910), and younger seniors (65- to 74-year-olds, n = 737) for which data were available for analysis (Table 1). Plaque was not recorded in a further 8 younger adolescents, 15 younger adults, and 58 younger seniors from the DMS • 6 analysis set. The most frequent reasons for this were lack of teeth, reluctance towards staining, and time constraints.

Examination procedure

The participants were asked to bring their oral hygiene devices to the examination. Once they had completed the computer-assisted questionnaire interview,[5] they brushed their teeth behind a screen at a mobile sink with their own devices or (in case they had forgotten them) with the devices provided (they had a choice between manual and electric toothbrushes, dental floss, interdental brushes of various sizes, and rubber picks). Toothbrushing was performed following the instruction to brush "as thoroughly as possible to ensure that the teeth are completely clean." No cleaning time was specified. As long as the participants con-

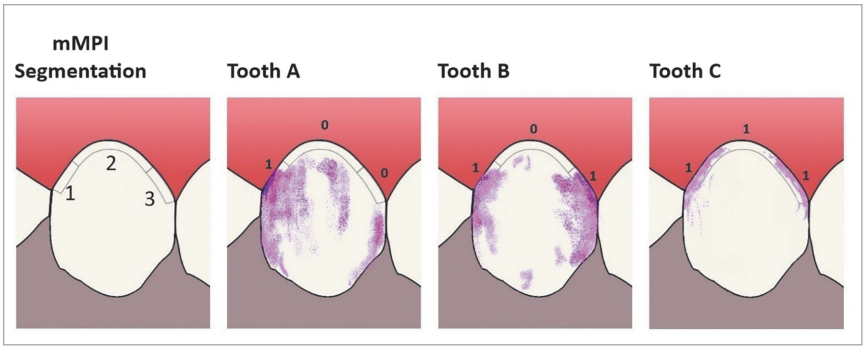

Fig 1 Recording of the modified Marginal Plaque Index (mMPI). In the case of tooth A, plaque is only present in segment 1, in tooth B in segments 1 and 3, and in tooth C in all three segments.

sented, the toothbrushing process was recorded using a tablet PC, which also acted as a mirror. When they had finished they told the assistant, and were then brought to the clinical examination.

Measurement methods

When the other dental assessments were finished, the plaque was stained using Mira-2-Tone pellets (Hager & Werken) without any prior relative drying, and the modified Marginal Plaque Index (mMPI; see Fig 1) was recorded.[6] Training and calibration for recording this index were performed using images, and the details on this are reported separately.[5]

Variables

The gingival margin was subdivided both at the inner and outer surfaces, into three segments: distal, cervical, mesial. Each segment was recorded as to whether plaque was present or not (Fig 1). The values were then summarized and expressed as a percentage of segments colonized by plaque (mMPI).

Statistical analysis

For the epidemiologic description, mean values with associated 95% confidence intervals (CIs) per age group were calculated based on the individual mMPI values; for this purpose, a weighted dataset was used. The aim was to compensate for different probabilities in the selection of subjects and differences in gender, age, and region compared to the population in Germany by using the weighted dataset. Numbers (n) are provided without weighting. Within the age groups, subgroup analyses were conducted for self-reported demographic, behavioral, and dental treatment-related parameters. Response categories were grouped together where appropriate and possible. This was to improve clarity and to avoid single values referring to a very small subset. Values that refer to less than 50 persons are not reported.

Before analyzing the overall data, sensitivity analyses were performed with respect to the omission of:

- plaque data recorded before recalibration
- individual investigators
- people with fewer than 20 teeth.

None of these sensitivity analyses revealed that these factors significantly affected the overall result. Therefore, the overall results are presented below for all persons in the three age groups for whom analyzable plaque data were available.

Detailed information on data handling and statistical methods has been described previously.[7]

Results

Table 1 depicts the characteristics of the study participants in terms of demographic data, self-reported oral hygiene behavior, and self-reported dental care experience. Almost all participants reported brushing their teeth at least once a day. More than 40% of all age groups stated that they use an electric toothbrush alone or alongside a manual one. Around 80% of adults and younger seniors reported that they had previously undergone professional tooth cleaning. Only a minority of these groups reported having had periodontal treatment. Table 2 illustrates the mean values of the mMPI after best possible brushing in relation to demographic data. Across all three age groups, there was a 95% probability that they ranged from 42.2% to 53.2%. Accordingly, plaque persisted on approximately half of the segments after brushing. Younger adolescents exhibited higher values than the younger adults and younger seniors. Older girls and younger female seniors achieved lower plaque levels than their male counterparts. Higher education status was associated with lower plaque lev-

Table 2 Modified Marginal Plaque Index (mMPI) in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds) overall, and by gender and education group

Age group	No. of participants (n)	mMPI					
		Total	Gender		Education group		
			Male	Female	Low	Medium	High
12-year-olds	948	51.5 (49.7; 53.2)	53.7 (51.3; 56.1)	49.0 (46.6; 51.5)	62.4 (57.4; 67.3)	53.6 (50.9; 56.2)	47.2 (44.4; 49.9)
35- to 44-year-olds	910	43.9 (42.3; 45.5)	43.3 (41.1; 45.6)	44.4 (42.1; 46.6)	48.8 (43.1; 53.7)	44.3 (42.0; 46.6)	41.4 (39.0; 43.9)
65- to 74-year-olds	737	44.3 (42.2; 46.3)	48.9 (45.9; 51.9)	40.0 (37.3; 42.8)	50.3 (45.9; 54.8)	44.9 (41.7; 48.1)	37.1 (33.7; 40.5)

Data are presented as unweighted numbers (n) and weighted means (with 95 % confidence intervals) for dentate subjects with valid plaque findings. Two gender-diverse individuals are included in the total column and the education groups, but not in the gender categories.

Table 3 Modified Marginal Plaque Index (mMPI) in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds) by the different areas of the mouth

Variable	12-year-olds	35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)	948	910	737
mMPI, anterior teeth (% segments with plaque)	48.3 (46.4; 50.2)	35.0 (33.2; 36.8)	41.2 (39.0; 43.4)
mMPI, premolars (% segments with plaque)	45.0 (43.1; 46.9)	42.6 (40.9; 44.3)	42.6 (40.3; 44.8)
mMPI, molars (% segments with plaque)	65.6 (63.7; 67.4)	59.2 (57.4; 60.9)	52.0 (49.4; 54.5)

Data are presented as unweighted numbers (n) and weighted means (with 95 % confidence intervals) for dentate subjects with valid plaque findings.

els in all groups. Almost complete oral cleanliness (mMPI ≤ 10%[8]) was rarely the case (in 5.9% of younger adolescents, 7.0% of younger adults, and 10.8% of younger seniors). Table 3 shows the distribution of plaque in the different areas of the mouth. In all age groups molars showed higher values than premolars or anterior teeth.

Table 4 presents the mMPI values after brushing in relation to self-reported parameters of behavior. Just under 15% of respondents brush their teeth only once a day. They had higher plaque levels in comparison to the majority who self-reported brushing at least twice a day. Minor differences were found with respect to the type of toothbrush used at home (electric, manual, or both).

Younger adults and seniors were asked whether they had ever undergone professional tooth cleaning or periodontal treatment. Those who responded positively to these questions had lower scores than those who responded negatively. This difference was greater for professional tooth cleaning (Table 3).

Discussion

Past DMS have shown that brushing teeth daily is an integral part of everyday routine for the German population.[1] This was confirmed by the latest data. Nevertheless, data also show that the age groups studied are still unable to achieve oral cleanliness, even when encouraged to brush to the best of their ability. To the present authors' knowledge, this is the first study to examine oral hygiene skills in a population sample. Comparable findings from laboratory studies[9,10] and the sensitivity analyses confirm that the results cannot simply be explained by the field conditions and the associated complications in data assessment. Neither of these give an indication of a relevant bias in the data reported here. Hence, there is a skill deficit in all three age groups in terms of the effectiveness of plaque removal. At the same time oral hygiene motivation is good, as measured by the frequency of daily oral hygiene, among others. This skill deficit is also present when an electric toothbrush is used. It affects all areas of the mouth, although more plaque remains on the molars than in the more anterior areas.

The differences observed in terms of demographics, behavior, and dental treatment are rather small. The most prominent factor here is the considerable education gradient, especially among younger seniors and younger adolescents. However, even in the group of younger seniors with a high education status, the plaque values were considerably higher than those attained by dental staff using manual aids alone.[8]

Table 4 Modified Marginal Plaque Index (mMPI) in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds), by oral hygiene behavior and dental care experience

Variable		mMPI		
		12-year-olds	35- to 44-year-olds	65- to 74-year-olds
No. of participants (n)		948	910	737
Tooth brushing (frequency)*	≥ 2 times daily	50.7 (48.8; 52.6)	43.3 (41.5; 45.1)	41.7 (39.5; 43.9)
	Once daily	57.0 (52.3; 61.7)	46.1 (42.4; 49.8)	53.3 (47.5; 59.2)
Type of toothbrush used†	Electric	50.6 (47.7; 53.5)	41.8 (39.5; 44.1)	41.0 (37.9; 44.0)
	Manual	53.3 (50.8; 55.9)	46.1 (43.6; 48.7)	48.0 (44.8; 51.3)
	Both	48.8 (44.2; 53.5)	44.9 (40.0; 49.8)	34.9 (29.2; 40.6)
Professional tooth cleaning (utilization)‡	Yes	NA	41.8 (40.0; 43.5)	42.8 (40.6; 45.0)
	No	NA	51.9 (48.4; 55.3)	48.5 (43.1; 53.9)
Lifetime periodontal treatment (utilization)‡	Yes	NA	43.1 (38.5; 47.6)	42.3 (38.5; 46.1)
	No	NA	43.8 (42.1; 45.5)	44.7 (42.2; 47.2)

Data are presented as unweighted numbers (n) and weighted means (with 95% confidence intervals) for dentate subjects with valid plaque findings.
*Less than once daily for less than 50 people.
†No toothbrush for less than 50 people.
‡Answer "Don't know" for less than 50 people in each case.
NA, not available.

Therefore, the existing data provide no reason to believe that only certain groups lack effective oral hygiene. Efforts to improve the situation should thus be made on a population-wide basis.

Further research is needed to identify which measures are most appropriate. There is still little reliable data on this.[9,11] Analysis of the videos showing how the people brushed could provide further information and will be published later. The high incidence of oral hygiene deficiencies should prompt dental staff to regularly assess patients' oral hygiene skills and help them to improve where necessary. Drawing their attention to skill deficits and associated knowledge gaps[12] may be a first step, as patients often appear to be unaware of these.[13]

Conclusion

For the first time a German Oral Health Study (DMS • 6) not only assessed self-reported frequency of toothbrushing, but also plaque after best possible brushing and thus toothbrushing skills. The data reveal that there is virtually no need for additional action when it comes to the "whether" of brushing teeth, but there is a need for action when it comes to the "how." Although most of the population brush their teeth several times a day, they fail to achieve oral cleanliness. This highlights the need for additional action in research and practice.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there is no conflict of interests according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. RD is a member of the scientific advisory board of the DMS • 6, responsible for developing the described clinical examinations and author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. JMS is a member of the scientific advisory board of the DMS • 6 and co-author of the manuscript.

References

1. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

2. Micheelis W, Geyer S. Prävalenzen und Strukturen mundgesundheitlicher Risikofaktoren in den vier untersuchten Altersgruppen. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016;S:195–212.

3. Micheelis W, Reich E (eds). Dritte Deutsche Mundgesundheitsstudie (DMS III). Ergebnisse, Trends und Problemanalysen auf der Grundlage bevölkerungsrepräsentativer Stichproben in Deutschland 1997. Cologne: Deutscher Ärzte-Verl., 1999.

4. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl):S4–S12.

5. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl): S14–S21.

6. Weik U, Eidenhardt Z, Deinzer R. Making plaque assessment easier – a validation study of simplified versions of the Marginal Plaque Index. BMC Oral Health 2024;24:1377.

7. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

8. Deinzer R, Schmidt R, Harnacke D, et al. Finding an upper limit of what might be achievable by patients: oral cleanliness in dental professionals after self-performed manual oral hygiene. Clin Oral Invest 2018;22:839–846.

9. Deinzer R, Weik U, Eidenhardt Z, Leufkens D, Sälzer S. Manual toothbrushing techniques for plaque removal and the prevention of gingivitis: a systematic review with network meta-analysis. PLoS One 2024;19:e306302.

10. Weik U, Shankar-Subramanian S, Sämann T, Wöstmann B, Margraf-Stiksrud J, Deinzer R. "You should brush your teeth better": a randomized controlled trial comparing best-possible versus as-usual toothbrushing. BMC Oral Health 2023;23:456.

11. Sälzer S, Graetz C, Dörfer CE, Slot DE, van der Weijden FA. Contemporary practices for mechanical oral hygiene to prevent periodontal disease. Periodontol 2000 2020;84:35–44.

12. Deinzer R, Jordan AR. Periodontal health literacy in Germany: Results of a telephone survey. Int J Dent Hyg 2024;22:887–896.

13. Eidenhardt Z, Busse S, Margraf-Stiksrud J, Deinzer R. Patients' awareness regarding the quality of their oral hygiene: development and validation of a new measurement instrument. BMC Oral Health 2022;22:629.

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Renate Deinzer

Renate Deinzer (Mrs/she/her), Professor and Head of Institute, Institute of Medical Psychology, Department of Medicine, Justus-Liebig-University Giessen, Giessen, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Jutta Margraf-Stiksrud Senior Lecturer, Department of Psychology, Philipps University of Marburg, Marburg, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, 50931 Cologne, Germany.
Email: dms6@idz.institute

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Oral health and dietary habits: results of the 6th German Oral Health Study (DMS • 6)

Jutta Margraf-Stiksrud, Dr phil/A. Rainer Jordan, Prof Dr med dent, MSc/Kathrin Kuhr, Dr rer medic/
Renate Deinzer, Prof Dr rer nat

Objectives: Dietary habits have significant implications for oral health, with the consumption of sugar-rich foods being strongly associated with caries. However, additional factors must be considered to fully establish their harmful effects. These relationships are examined in three age groups of the 6th German Oral Health Study (DMS • 6). **Method and materials:** Dietary habits were assessed using the short form of the Marburg Sugar Index (MSI-S), which comprises six questions regarding food consumption frequencies in various contexts. Responses provide insight into the degree of cariogenic eating behavior. In addition to demographic factors (gender, education status, migration history), clinical variables such as caries experience (decayed, missing, filled teeth [DMFT] index), plaque accumulation (modified Marginal Plaque Index [mMPI]), and the number of remaining teeth were included. **Results:** No direct relationship between the extent of cariogenic dietary habits (MSI-S total score) and clinical variables was observed in any of the examined age groups (n = 870 younger adolescents [12-year-olds], n = 853 younger adults [35- to 44-year-olds], and n = 730 younger seniors [65- to 74-year-olds]). Gender and education status also showed no significant differences. However, 12-year-olds with a migration history exhibited higher MSI-S scores compared to those without. Analyzing extreme groups (the top and bottom 10% of MSI-S scores), systematic differences in caries experience were observed among 12-year-olds and younger seniors, and in plaque levels among younger seniors. Younger adults showed no significant differences in clinical variables, even within extreme groups. **Conclusion:** The MSI-S scores demonstrated that particularly cariogenic dietary habits, as opposed to more favorable ones (extreme groups), are associated with increased caries experience. This was especially evident among 12-year-olds but also observed in younger seniors. The lack of differences among adults as well as the absence of significant associations between dietary habits and clinical variables in the overall groups suggest that the impact of cariogenic diets on oral health is moderated by additional variables, such as oral hygiene practices and dental service utilization. Migration history was identified as a relevant factor among 12-year-olds. The detrimental effects of cariogenic dietary habits on oral health are most evident when analyzed in the context of additional influencing factors and stratified by target groups. Promoting oral health awareness regarding nutrition is particularly important for adolescents and seniors. *(Quintessence Int 2025;56(Suppl):S88–S94; doi: 10.3290/j.qi.b5982015)*

Keywords: dental care, dental caries, dental plaque, dentists, diet, DMS 6, Marburg Sugar Index, nutrition

Dietary habits are crucial not only for general physical health but also specifically for oral health. The consumption of certain foods, particularly dietary sugars, remains a significant risk factor for the development of caries. In 2015, the World Health Organization (WHO) lowered its recommendation for daily sugar intake from less than 10% to less than 5% of total energy intake, citing additional positive health outcomes.[1]

Against this background, the German Oral Health Studies (DMS I to V) also assessed aspects of dietary behavior and their relationships with oral health.[2-6] In DMS IV and V, the focus was placed on the consumption of snacks and sugar- and acid-rich beverages. A consistent association with caries experience was observed among younger adolescents (12-year-olds); however, in DMS V, this association was limited to beverages. Evidently,

Table 1 MSI-S total score in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds) by gender, education group, and migration history

Variable		12-year-olds		35- to 44-year-olds		65- to 74-year-olds	
		No. of participants (n)	MSI-S	No. of participants (n)	MSI-S	No. of participants (n)	MSI-S
Total		871	2.4 ± 0.5	854	2.1 ± 0.5	730	1.8 ± 0.5
Gender*	Male	433	2.4 ± 0.5	428	2.1 ± 0.5	345	1.8 ± 0.5
	Female	437	2.4 ± 0.5	425	2.1 ± 0.5	385	1.8 ± 0.4
Education group	Low	77	2.6 ± 0.6	78	2.3 ± 0.6	150	1.9 ± 0.5
	Medium	408	2.4 ± 0.5	397	2.1 ± 0.5	351	1.7 ± 0.4
	High	371	2.3 ± 0.5	372	2.1 ± 0.5	225	1.8 ± 0.5
Migration history	People with migration history	208	2.5 ± 0.6	187	2.1 ± 0.6	100	1.7 ± 0.4
	People without migration history	662	2.3 ± 0.5	652	2.1 ± 0.5	624	1.8 ± 0.5

Data are presented as number (n) or mean ± standard deviation based on unweighted data for participants with valid information on MSI-S.
*Data of two gender-diverse individuals are not presented.
MSI-S, Marburg Sugar Index short scale.

harmful dietary habits—particularly frequent sugar consumption and its effects on the oral microbiome—must be analyzed alongside other oral health-related behaviors (eg, oral hygiene practices, routine dental check-ups) to explain caries experience comprehensively. This multifactorial interplay has also been highlighted by other epidemiologic findings.[7,8]

One of the aims of the 6th German Oral Health Study (DMS • 6) was therefore to assess dietary behavior in a new way, together with other factors, and to analyze systematic relationships with oral health indicators across different age groups.

Method and materials

The methodologic approach for the social science survey and clinical examinations is presented in separate articles.[9,10] DMS • 6 has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). The study is registered in the German Clinical Trials Register (registration number DRKS00028701).

Measurement and variables

Dietary habits were assessed using the short form of the Marburg Sugar Index (MSI-S) as part of the written survey. The short form, specifically designed for epidemiologic studies and consisting of six questions, has been shown to be equivalent in terms of item characteristics and reliability to the long form comprising 25 items.[11]

Clinical parameters used to examine associations with the MSI-S included caries experience (decayed, missing, filled teeth [DMFT] index), plaque accumulation (modified Marginal Plaque Index [mMPI]), and dentition/tooth loss (among the 65- to 74-year-olds). Demographic factors such as gender, education status, and migration history were also considered. The definitions of these variables are described in detail elsewhere.[12-15]

Sample

For the data analysis, participants with complete MSI-S data were selected from those who met the inclusion criteria for the DMS • 6 analysis set. Data from 871 younger adolescents (12-year-olds), 854 younger adults (35- to 44-year-olds), and 730 younger seniors (65- to 74-year-olds) were included in the analysis. Participants with missing MSI-S data (n = 158) and those with incomplete responses (fewer than six questions answered: n = 69) were excluded. Overall, 91.5% of participants in the target age groups completed the MSI-S in full.

Statistical analysis

To assess the reliability of the MSI-S, Cronbach alpha was calculated. This measure evaluates the internal consistency of the scale by assessing the homogeneity of its individual components. Descriptive statistics of the MSI-S total score, including mean and standard deviation (SD), were reported for each age

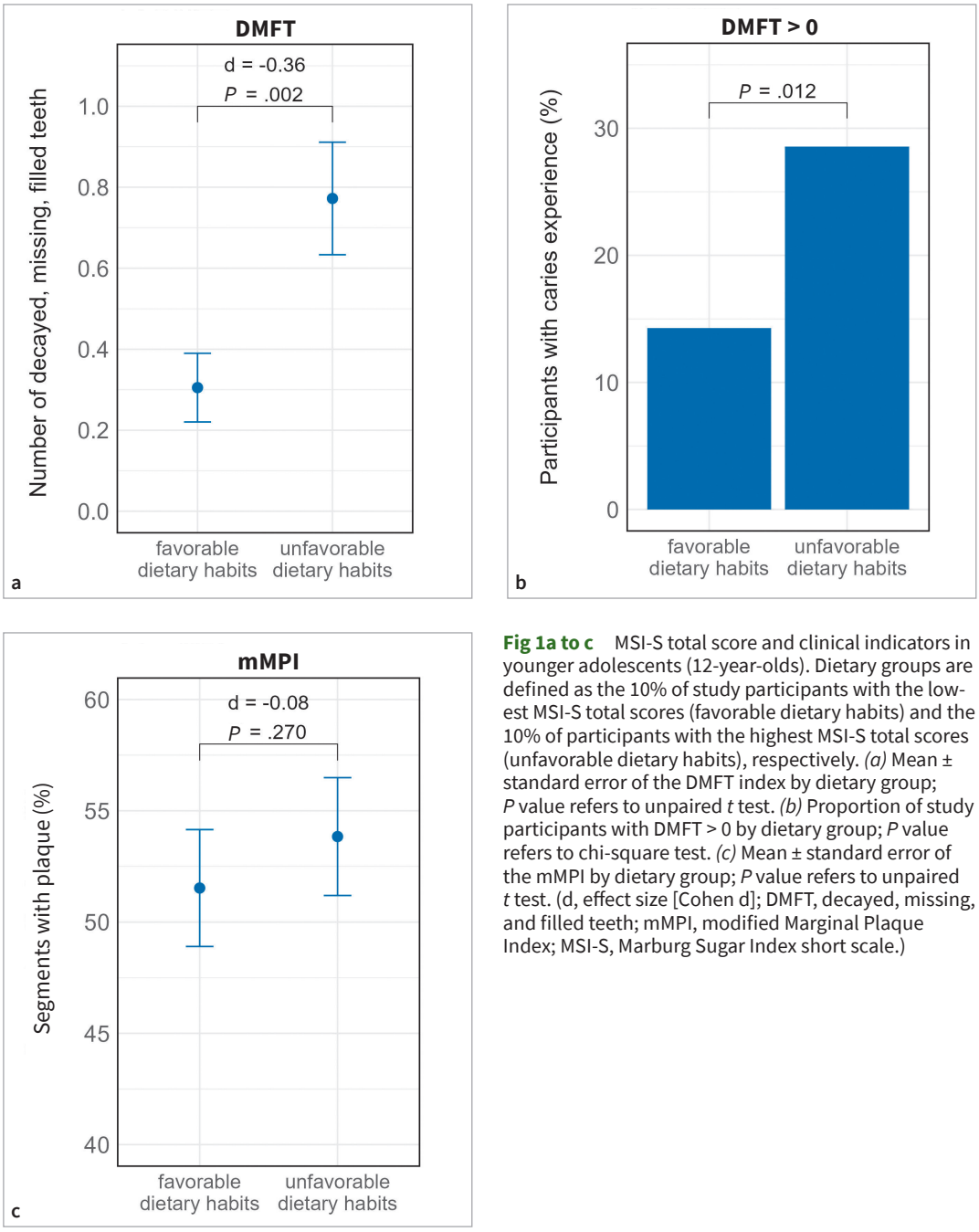

Fig 1a to c MSI-S total score and clinical indicators in younger adolescents (12-year-olds). Dietary groups are defined as the 10% of study participants with the lowest MSI-S total scores (favorable dietary habits) and the 10% of participants with the highest MSI-S total scores (unfavorable dietary habits), respectively. *(a)* Mean ± standard error of the DMFT index by dietary group; *P* value refers to unpaired *t* test. *(b)* Proportion of study participants with DMFT > 0 by dietary group; *P* value refers to chi-square test. *(c)* Mean ± standard error of the mMPI by dietary group; *P* value refers to unpaired *t* test. (d, effect size [Cohen d]; DMFT, decayed, missing, and filled teeth; mMPI, modified Marginal Plaque Index; MSI-S, Marburg Sugar Index short scale.)

group and stratified by gender, education group, and migration history within each group. Potential associations between the MSI-S total score and clinical parameters were analyzed using Spearman rho correlation coefficients. Additionally, comparisons between extreme groups (the top and bottom 10% of MSI-S scores within each age group) were conducted. Differences between extreme groups were tested using *t* tests for continuous variables and chi-square tests for categorical variables. Cohen d was reported as a measure of effect size. The reported *P* values are exploratory and provided for descriptive purposes; *P* values < .05 were considered statistically meaningful.

Sensitivity analysis

Only participants who answered all six MSI-S items were included in the analysis dataset. A sensitivity analysis was performed to determine whether including participants who answered only one to five items would alter the distribution

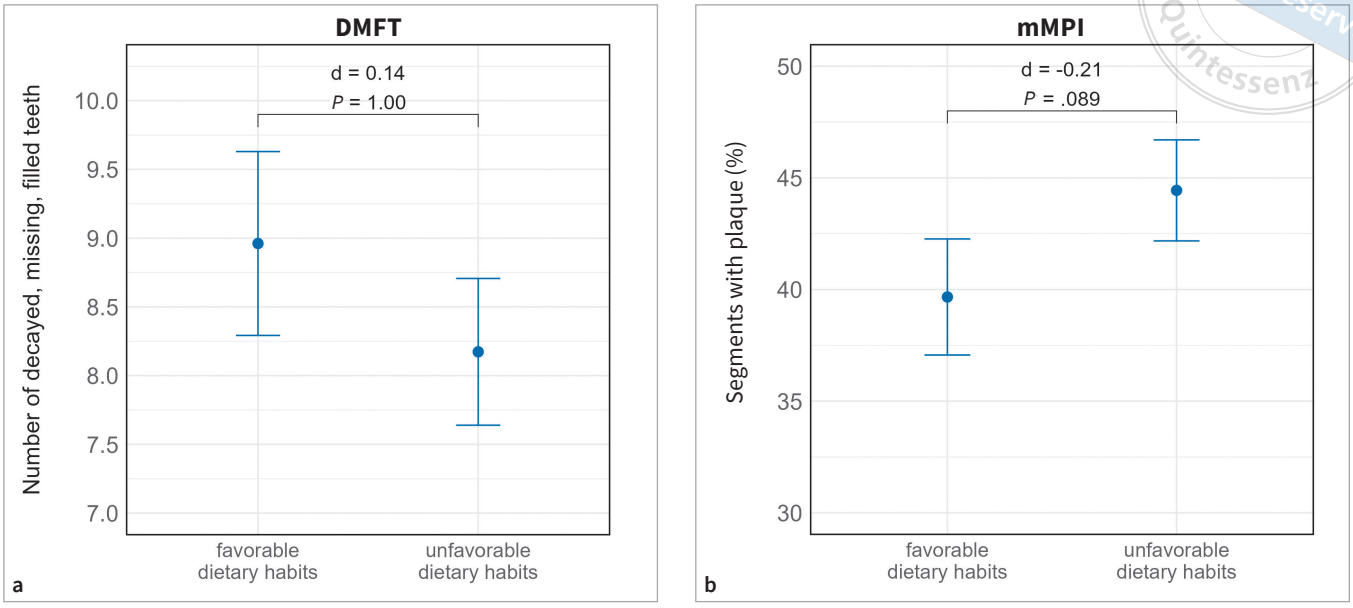

Fig 2a and b MSI-S total score and clinical indicators in younger adults (35- to 44-year-olds). Dietary groups are defined as the 10% of study participants with the lowest MSI-S total scores (favorable dietary habits) and the 10% of participants with the highest MSI-S total scores (unfavorable dietary habits), respectively. *(a)* Mean ± standard error of the DMFT index by dietary group; *P* value refers to unpaired *t* test. *(b)* Mean ± standard error of the mMPI by dietary group; *P* value refers to unpaired *t* test. (d, effect size [Cohen d]; DMFT, decayed, missing, filled teeth; mMPI, modified Marginal Plaque Index; MSI-S, Marburg Sugar Index short scale.)

parameters of the MSI-S total score. No indication of bias in the overall results was observed.

Analyses were conducted separately for each age group and based on unweighted data. Detailed information regarding data processing and statistical methods is provided in a separate methods article.[12]

Results

Reliability of the MSI-S across age groups

The reliability of the MSI-S scale (internal consistency, Cronbach alpha) was 0.41 for younger adolescents, 0.55 for younger adults, and 0.45 for younger seniors. They thus achieved a satisfactory reliability for the short form, which corresponds statistically to what would be expected with an item reduction from 25 to 6 items, and which is still sufficient for epidemiologic purposes.

Associations between the MSI-S and demographic factors

Table 1 provides an overview of the mean MSI-S total scores across the three age groups, as well as within these groups by gender (female/male), education groups (high/medium/low), and migration history (with migration history/without migration history). Differences in the total scores across age groups indicate varying frequencies of snack food consumption. Nevertheless, "sweet rolls" and "chocolate while watching TV" were the most frequently consumed items in all groups (data not shown).

Mean MSI-S scores were similar for female and male participants in all age groups. Differences between education and migration groups were small. Participants with the lowest education status consistently showed the highest MSI-S total scores, although the number of participants in this group was also the smallest. Systematic differences between participants with and without migration history were observed only among younger adolescents. In this group, migration history was associated with higher MSI-S total scores.

Associations between the MSI-S and clinical parameters in the overall cohorts

No significant correlations between MSI-S total scores and caries experience, plaque, or tooth loss were observed among younger adolescents and younger adults (Spearman rho ranging from 0.014 to 0.099). Among younger seniors, there was a very small but statistically meaningful correlation with the DMFT index (Spearman rho = 0.14).

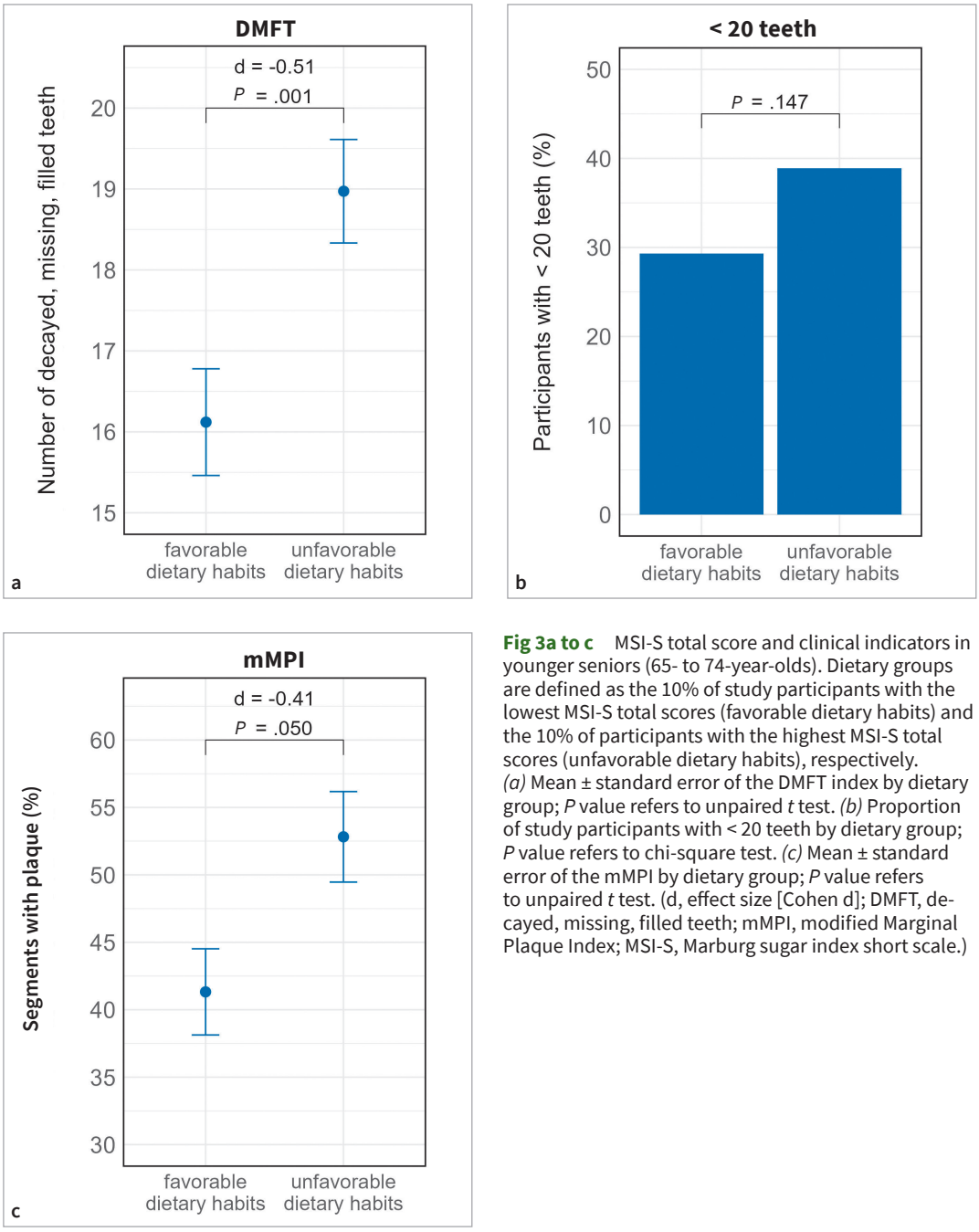

Fig 3a to c MSI-S total score and clinical indicators in younger seniors (65- to 74-year-olds). Dietary groups are defined as the 10% of study participants with the lowest MSI-S total scores (favorable dietary habits) and the 10% of participants with the highest MSI-S total scores (unfavorable dietary habits), respectively. *(a)* Mean ± standard error of the DMFT index by dietary group; *P* value refers to unpaired *t* test. *(b)* Proportion of study participants with < 20 teeth by dietary group; *P* value refers to chi-square test. *(c)* Mean ± standard error of the mMPI by dietary group; *P* value refers to unpaired *t* test. (d, effect size [Cohen d]; DMFT, decayed, missing, filled teeth; mMPI, modified Marginal Plaque Index; MSI-S, Marburg sugar index short scale.)

Associations between the MSI-S and clinical parameters in extreme groups

Figures 1 to 3 illustrate the results of the extreme group comparisons for younger adolescents, younger adults, and younger seniors.

Among younger adolescents, systematic differences in caries experience were found between groups with low and high MSI-S total scores. The mean DMFT index was higher for younger adolescents with more cariogenic eating behaviors, though the effect size was small (d = −0.36, Fig 1a). Similar patterns were observed when comparing caries-free adolescents to those with caries experience (Fig 1b). However, no differences in plaque levels were found between the extreme groups (Fig 1c).

For younger adults, clinical indicators did not differ systematically between the extreme groups of MSI-S total scores (Fig 2).

In the younger senior group, systematic differences were identified between the extreme groups for both the DMFT index

and mMPI, with small to moderate effect sizes (d = −0.51 and d = −0.41, respectively; Fig 3).

The observed differences in extreme groups were not attributable to differing distributions of education status within the groups for any age cohort. However, among younger adolescents, the association with migration history was a confounding factor. Differences in DMFT scores and caries experience related to cariogenic dietary habits were only observed in younger adolescents with migration history. Among younger adolescents without migration history, the differences between dietary groups disappeared.

Discussion

The use of a short form of the dietary behavior questionnaire (Marburg Sugar Index, MSI-S) within the DMS • 6 study yielded a solid data foundation for analysis, with 91.5% of participants in the younger adolescent, younger adult, and younger senior age groups providing complete responses. The overall score proved sufficiently reliable and sensitive in all three age groups to reveal associations with demographic and clinical variables, even if these were sometimes apparent only in extreme groups.

Among younger adolescents, a systematic difference in caries experience was observed between the two dietary groups. The link between sugar consumption and oral health in children and adolescents is well documented in the literature[16-18] and can be considered established. The current findings confirm that unhealthy dietary habits remain a risk indicator for the development of caries in this age group. However, it is crucial to recognize that additional factors moderate this relationship. This is particularly evident in the case of migration history. In the absence of migration history, there was no significant association between MSI-S total scores and caries experience in the DMS • 6 cohort, as these younger adolescents exhibited minimal caries.

Younger seniors with more frequent consumption of cariogenic foods also showed higher caries and plaque levels. Unbalanced and monotonous dietary habits are generally recognized as health risks for seniors and are associated with chewing and eating difficulties.[19] However, there is little prior evidence of a specific relationship between cariogenic dietary habits and caries or plaque in this age group. DMS • 6 was the first to reveal these correlations. These findings support the promotion of the common risk factor approach, according to which preventive messages should be formulated jointly by general and dental medicine, from a nutritional perspective.[20]

While associations between more and less harmful dietary habits and clinical indicators were found in younger adolescents and younger seniors, no such relationship could be statistically demonstrated among younger adults. Although the absolute amount of plaque was higher in individuals with unfavorable dietary habits, the caries burden was inversely related. In this age group—which is likely to have the greatest autonomy in managing its oral health—the multitude of other factors involved (both demographic and behavioral) may mask or compensate for the consequences of consuming cariogenic foods.

Conclusion

The DMS • 6 confirms an increased prevalence of caries among younger adolescents in the (extreme) group of individuals with frequent consumption of cariogenic foods. This finding also applies to younger seniors but not to younger adults. Educational efforts on oral health-promoting nutrition should play a central role in prevention programs, not only for adolescents but also for seniors.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. JMS and RD are members of the scientific advisory board of the DMS • 6, responsible for the development of the questionnaire used, and authors of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for the development of the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript.

References

1. World Health Organization. Guideline: Sugars intake for adults and children. Geneva: World Health Organization, 2015.

2. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in der Bundesrepublik Deutschland. Ergebnisse des nationalen IDZ-Survey 1989. Cologne: Deutscher Ärzte-Verl., 1991.

3. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in Ostdeutschland. Ergebnisse des IDZ-Ergänzungssurvey 1992. Cologne: Deutscher Ärzte-Verl., 1993.

4. Micheelis W, Reich E (eds). Dritte Deutsche Mundgesundheitsstudie (DMS III). Ergebnisse, Trends und Problemanalysen auf der Grundlage bevölkerungsrepräsentativer Stichproben in Deutschland 1997. Cologne: Deutscher Ärzte-Verl., 1999.

5. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006.

6. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

7. Yu OY, Lam WY-H, Wong AW-Y, Duangthip D, Chu C-H. Nonrestorative management of dental caries. Dent J 2021;9:121.

8. van Loveren C. Sugar restriction for caries prevention: amount and frequency. Which is more important? Caries Res 2019; 53:168–175.

9. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

10. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl): S14–S21.

11. Margraf-Stiksrud J, Pieper K, Deinzer R. Assessing sugar intake rapidly - a short form of the Marburg Sugar Index (MSI). BMC Oral Health 2023;23:702.

12. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

13. Jordan AR, Meyer-Lückel H, Kuhr K, Sasunna D, Bekes K, Schiffner U. Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S30–S39.

14. Deinzer R, Jordan AR, Kuhr K, Margraf-Stiksrud J. Oral hygiene behavior and toothbrushing skills: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S82–S87.

15. Aarabi G, Schenk L, Kuhr K, Borof K, Jordan AR, Lieske B. Disease and care prevalence of people with migration history: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl): S120–S125.

16. Pieper K, Winter J, Heinzel-Gutenbrunner M, Margraf-Stiksrud J. Association between a new sugar index and caries experience: results of a cross-sectional field study. Caries Res 2019;53:160–167.

17. Hancock S, Zinn C, Schofield G. The consumption of processed sugar- and starch-containing foods, and dental caries: a systematic review. Eur J Oral Sci 2020; 128:467–475.

18. Moynihan PJ, Kelly SAM. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. J Dent Res 2014;93:8–18.

19. Shen J, Qian S, Huang L, et al. Association of the number of natural teeth with dietary diversity and nutritional status in older adults: a cross-sectional study in China. J Clin Periodontol 2023;50:242–251.

20. Heilmann A, Sheiham A, Watt RG, Jordan RA. Common risk factor approach – Ein integrierter bevölkerungsbezogener und evidenzbasierter Ansatz zum Ausgleich sozialer Ungleichheiten in der Mundgesundheit. Gesundheitswesen 2016;78:672–677.

Jutta Margraf-Stiksrud

Jutta Margraf-Stiksrud Senior lecturer, Department of Psychology, Philipps University of Marburg, Marburg, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Renate Deinzer (Mrs/she/her), Professor and Head of Institute, Institute of Medical Psychology, Department of Medicine, Justus-Liebig-University Giessen, Giessen, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

Relationship between smoking and oral health: results of the 6th German Oral Health Study (DMS • 6)

Laura Krause, Dr phil/Anne Starker, Dr rer medic/Katrin Hertrampf, Prof Dr med dent, MPH, MME/ Nicolas Frenzel Baudisch, Dr rer pol/ A. Rainer Jordan, Prof Dr med dent, MSc/Vinay Pitchika, PhD/ Kathrin Kuhr, Dr rer medic

Objectives: Smoking is the most significant individual health risk and the leading cause of premature mortality in industrialized nations. International studies demonstrate that smoking also affects oral health adversely. This study aimed to investigate the association between smoking and oral health using population-representative data for Germany. **Method and materials:** The data source was the 6th German Oral Health Study (DMS • 6), conducted between 2021 and 2023. Data from a total of 2,135 individuals were included in the analyses. The distribution of sociodemographic characteristics (gender, age, education status), oral health behaviors (frequency of toothbrushing, interdental cleaning, and dental visits), and oral health-related parameters (self-assessed oral health, oral health-related quality of life, root caries, periodontitis, oral mucosal changes, and the number of teeth present) were reported separately for smoking status (daily smokers, former smokers, and never smoked). To estimate the associations between smoking status and oral health outcomes, mixed-effects regression models were employed. **Results:** Daily smokers exhibited worse outcomes in both self-assessed oral health parameters and clinical oral health measures compared to individuals who had never smoked. These associations persisted even after adjusting for sociodemographic factors and oral health behaviors. Similar trends were observed for former smokers compared to never smokers. **Conclusion:** Smoking is a well-established risk factor for poorer oral health. The findings of DMS • 6 confirm this association and are consistent with those of other national and international studies. Given the strong impact of smoking on oral health, comprehensive measures to curb smoking are essential. Evidence-based behavioral and structural preventive interventions exist to reduce tobacco consumption and promote smoking cessation. Dental offices can also contribute to tobacco prevention and cessation by providing brief counseling on the risks of smoking for both oral and general health. *(Quintessence Int 2025;56(Suppl):S96–S103; doi: 10.3290/j.qi.b5982019)*

Keywords: dental care, dentists, DMS 6, mouth diseases, periodontitis, quality of life, smoking cessation, tobacco use

Smoking remains prevalent among adults in the population in Germany, despite a general decline in the proportion of smokers.[1,2] According to the German Health Update study (GEDA 2023) conducted by the Robert Koch Institute (RKI), the smoking rate among adults in Germany is 29%.[3]

Smoking is the most significant single health risk in industrialized nations and a leading cause of premature mortality. Diseases more commonly found among smokers include cardiovascular, respiratory, and cancer-related conditions. For example, nearly one-fifth of all cancer diagnoses in Germany are attributed to smoking,[4] and in 2021, approximately 99,000 people in Germany died from tobacco-related causes.[5] Furthermore, smoking negatively impacts the immune system, metabolism, skeletal structure, eyes, fertility, and oral health.[6]

Smoking harms oral health in various ways: it is a risk factor for the development of oral precursor lesions and subsequent oral cavity tumors, oral mucosal lesions, root caries, periodontal disease, and gingival recession.[7,8] Moreover, smokers exhibit impaired healing following periodontal treatment. Smoking cessation reduces the risk of oral diseases and associated impairments. Some oral mucosal lesions may regress after quitting smoking.[7,9]

The present study aimed to analyze the association between smoking and oral health using recent data from the 6th German Oral Health Study (DMS • 6). A distinction is made between daily smokers, former smokers, and never smokers. Both self-assessed parameters, such as self-rated oral health and oral health-related quality of life, and clinical parameters, including root caries, periodontitis, oral mucosal changes, and the number of teeth present, were examined. The analyses were statistically controlled for sociodemographic factors and characteristics of oral health behavior. To date, such a comprehensive analysis of the association between smoking and oral health has not been conducted for Germany. This article therefore fills a research gap.

Method and materials

The DMS • 6 (2021 to 2023) is a nationally representative oral epidemiologic and social science survey. It aligns directly with the five previous German Oral Health Studies conducted by the Institute of German Dentists (Institut der Deutschen Zahnärzte, IDZ) since 1989.[10-14] The main objective of these studies has been to provide health reporting on oral diseases in Germany. The DMS • 6 is a combined cross-sectional and cohort study, and thus classified as an observational study. Details on the general methodology of the study are presented in separate articles.[15,16] The 6th German Oral Health Study (DMS • 6) has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

The analysis included study participants from the following age groups of the DMS • 6: older adolescents (20-year-olds, DMS • 6 cohort), younger adults (35- to 44-year-olds, DMS • 6 cross-section), older adults (43- to 52-year-olds, DMS • 6 cohort), and younger seniors (65- to 74-year-olds, DMS • 6 cross-section). Participants were included in the analyses if they met the inclusion criteria of the DMS • 6 analysis set (complete dental and caries examination, periodontal examination conducted on at least two quadrants) and provided valid information on smoking status. Occasional smokers (n = 112) and edentulous individuals (n = 38) were excluded from the analyses, as well as 12 participants with missing smoking status. Overall, data from 2,276 individuals were included in the descriptive analyses. Additionally, 141 participants were excluded from the regression analyses due to missing covariate data (11 of 333 older adolescents, 59 of 867 younger adults, 18 of 332 older adults, and 53 of 744 younger seniors). Finally, data from 2,135 participants were included in the models.

Variables

Smoking

Participants were asked whether they smoke. Response options included: "Yes, daily," "Yes, occasionally," "No, not anymore," and "I have never smoked." Individuals reporting daily smoking were subsequently asked about the number of cigarettes smoked per day and the age at which they started smoking. Former smokers were additionally asked about the age at which they started and stopped smoking.

Self-reported oral health parameters

The following self-assessed oral health parameters were used in the statistical analyses:

- self-assessment of oral health status (dichotomized response categories: "very good/good" vs "moderate/poor/very poor")
- oral health-related quality of life (OHIP-5,[17] dichotomized response categories: "never/rarely" vs "occasionally/often/always").

Dental-clinical parameters

Additionally, variables from the clinical examination were included in the analyses:

- root caries (yes/no)
- mean clinical attachment level (CAL, mm; < 3 mm/ ≥ 3 mm), partial-mouth protocol
- mean probing depth (PD, mm), partial-mouth protocol: index teeth with three measurement sites
- bleeding on probing (BOP, % of sites), partial-mouth protocol
- oral mucosal changes (yes/no; defined as the presence of at least one of the following suspected diagnoses: carcinoma, leukoplakia, oral lichen planus, smoker's keratosis)
- number of teeth (< 20 teeth/ ≥ 20 teeth).

Detailed definitions of these variables are described in other publications.[18-24]

Statistical analysis

Descriptive analyses of sociodemographic characteristics (gender, age, education status) and oral health behavior as well as

Table 1 Baseline characteristics of study participants by smoking status

Variable			Smoking status			
			Daily	Former	Never smoked	Total
No. of participants (n)			369	559	1,348	2,276
Sociodemographic characteristics	Gender	Female	166 (45.0%)	269 (48.1%)	745 (55.3%)	1,180 (51.8%)
		Male	202 (54.7%)	290 (51.9%)	602 (44.7%)	1,094 (48.1%)
		Diverse	1 (0.3%)	0 (0.0%)	1 (0.1%)	2 (0.1%)
		Missing	0	0	0	0
	Age, years		45.8 ± 15.2	55.8 ± 15.0	45.9 ± 17.6	48.3 ± 17.1
		Missing	0	1	1	2
	Age group	20-year-olds	48 (13.0%)	16 (2.9%)	269 (20.0%)	333 (14.6%)
		35- to 44-year-olds	182 (49.3%)	182 (32.6%)	503 (37.3%)	867 (38.1%)
		43-to 52-year-olds	50 (13.6%)	78 (14.0%)	204 (15.1%)	332 (14.6%)
		65- to 74-year-olds	89 (24.1%)	283 (50.6%)	372 (27.6%)	744 (32.7%)
		Missing	0	0	0	0
	Education group	Low	71 (20.4%)	77 (14.3%)	111 (8.7%)	259 (12.0%)
		Medium	215 (61.8%)	295 (54.6%)	718 (56.3%)	1,228 (56.8%)
		High	62 (17.8%)	168 (31.1%)	446 (35.0%)	676 (31.3%)
		Missing	21	19	73	113
Oral hygiene behavior	Tooth brushing (frequency)	≥ 2 times daily	263 (72.7%)	476 (85.9%)	1,158 (86.1%)	1,897 (83.9%)
		< 2 times daily	99 (27.3%)	78 (14.1%)	187 (13.9%)	364 (16.1%)
		Missing	7	5	3	15
	Interdental cleaning (frequency)	≥ once daily	78 (21.5%)	185 (33.4%)	376 (28.0%)	639 (28.3%)
		< once daily	284 (78.5%)	369 (66.6%)	969 (72.0%)	1,622 (71.7%)
		Missing	7	5	3	15
	Dental visits (frequency)	≥ once a year	293 (79.8%)	500 (89.8%)	1,208 (90.1%)	2,001 (88.4%)
		< once a year	74 (20.2%)	57 (10.2%)	132 (9.9%)	263 (11.6%)
		Missing	2	2	8	12

Data are presented as numbers (percentages) or means ± standard deviation based on unweighted data for dentate participants with valid information on smoking status; edentate individuals and occasional smokers were excluded.

oral health-related parameters were stratified by smoking status (daily, former, never smoked).

Mixed-effects regression models were employed to estimate the associations between smoking status (exposure; reference category: never smoked) and oral health-related outcomes. Depending on the distribution of the outcome variables, generalized linear models with a gamma distribution, Poisson regressions with robust standard errors, or fractional probit regressions were used. The models incorporated sociodemographic characteristics and oral health behaviors as fixed effects, and a composite regional variable as a random effect. All models were adjusted in a stepwise manner (see Table 3):

- Step 1: Unadjusted baseline models to assess the association between smoking status (exposure) and oral health-related outcomes.
- Step 2: Adjustment for gender (measured as gender identity), age (continuous), and education status (CASMIN classification; Comparative Analysis of Social Mobility in Industrial Nations; categorized into low, medium, and high education group[25]) to account for sociodemographic differences.

Table 2 Oral health-related characteristics by smoking status

Variable		Smoking status			Total
		Daily	Former	Never smoked	
Self-assessment of oral health status	Very good/good	210 (57.1%)	376 (67.3%)	1,050 (78.1%)	1,636 (72.0%)
	Moderate/poor/very poor	158 (42.9%)	183 (32.7%)	295 (21.9%)	636 (28.0%)
	Missing	1	0	3	4
Impaired OHRQoL	Never/rarely	208 (59.9%)	381 (70.7%)	976 (76.9%)	1,565 (72.6%)
	Occasionally/often/always	139 (40.1%)	158 (29.3%)	294 (23.1%)	591 (27.4%)
	Missing	22	20	78	120
Root caries*	Yes	131 (40.8%)	223 (41.1%)	353 (32.7%)	707 (36.4%)
	No	190 (59.2%)	320 (58.9%)	726 (67.3%)	1,236 (63.6%)
	Missing	0	0	0	0
Mean CAL, mm†		2.0 ± 1.5	2.0 ± 1.4	1.4 ± 1.1	1.7 ± 1.3
	CAL ≥ 3 mm	273 (80.8%)	415 (81.1%)	853 (65.4%)	1,541 (71.5%)
	CAL < 3 mm	65 (19.2%)	97 (18.9%)	451 (34.6%)	613 (28.5%)
	Missing	31	47	44	122
Mean PD, mm†		2.6 ± 0.8	2.6 ± 0.7	2.3 ± 0.5	2.4 ± 0.7
	Missing	20	24	29	73
BOP (% sites)†		18.9 ± 21.0	18.9 ± 21.2	15.8 ± 18.4	17.1 ± 19.6
	Missing	20	24	29	73
No. of teeth‡	< 20 teeth	51 (57.3%)	95 (33.6%)	101 (27.2%)	247 (33.2%)
	≥ 20 teeth	38 (42.7%)	188 (66.4%)	271 (72.8%)	497 (66.8%)
	Missing	0	0	0	0
Oral mucosa changes‡§	Yes	11 (12.4%)	13 (4.6%)	14 (3.8%)	38 (5.1%)
	No	78 (87.6%)	270 (95.4%)	358 (96.2%)	706 (94.9%)
	Missing	0	0	0	0

Data are presented as numbers (%) or means ± standard deviation based on unweighted data for dentate participants with valid information on smoking status; edentate individuals and occasional smokers were excluded.
BOP, bleeding on probing; CAL, clinical attachment level; OHRQoL, oral health-related quality of life; PD, probing depth.
*Not recorded in the age group of 20-year-olds.
†Partial-mouth protocol: index teeth with 3 measurement sites.
‡Only for the age group of 65- to 74-year-olds.
§Oral mucosa changes (≥ 1): suspected carcinoma, leukoplakia, oral lichen planus, or smoker's keratosis.

- Step 3: Additional adjustment for the frequency of toothbrushing (at least twice daily), interdental cleaning (at least once daily), and dental visits (at least once per year) to account for differences in oral health behavior.

Regression coefficients or prevalence ratios (PR) with corresponding 95% confidence intervals (CIs) and *P* values were reported.

Age groups were combined for the analyses, and unweighted cross-sectional data were used. For descriptive analyses, all available cases were included (available case analysis), while regression analyses were limited to cases with valid data for all relevant variables (complete case analysis). Gender-diverse individuals were not included in the regression analyses due to the small number of cases. Detailed information on data handling and statistical methods is described previously.[16]

Results

Table 1 illustrates the smoking status of the study population (daily, former, never smoked) stratified by sociodemographic character-

Table 3 Association analyses between smoking status (reference: never smoked) and oral health-related characteristics

Dependent variable		Step 1: crude estimate				Step 2: adjusted for sociodemographic characteristics**				Step 3: adjusted for sociodemographic characteristics** and characteristics of oral health behavior††			
		Daily		Former		Daily		Former		Daily		Former	
		Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value
Self-assessment of oral health status (ref. very good/good)*	Moderate/poor/ very poor	PR = 2.01 (1.70; 2.37)	< .001	PR = 1.50 (1.27; 1.78)	< .001	PR = 1.94 (1.61; 2.34)	< .001	PR = 1.29 (1.09; 1.54)	.003	PR = 1.80 (1.46; 2.23)	< .001	PR = 1.29 (1.09; 1.53)	.002
Impaired OHRQoL (ref. never/rarely)*	Occasionally/often/ always	PR = 1.72 (1.43; 2.07)	< .001	PR = 1.26 (1.10; 1.44)	.001	PR = 1.67 (1.36; 2.05)	< .001	PR = 1.22 (1.05; 1.41)	.010	PR = 1.59 (1.29; 1.95)	< .001	PR = 1.22 (1.05; 1.41)	.010
Root caries (ref. no)*§	Yes	PR = 1.21 (1.04; 1.41)	.015	PR = 1.20 (1.00; 1.43)	.052	PR = 1.39 (1.23; 1.56)	< .001	PR = 1.00 (0.85; 1.18)	.962	PR = 1.40 (1.25; 1.57)	< .001	PR = 1.00 (0.85; 1.18)	.990
Mean CAL, mm†‖		b = 0.32 (0.22; 0.43)	< .001	b = 0.32 (0.23; 0.41)	< .001	b = 0.34 (0.25; 0.44)	< .001	b = 0.09 (0.07; 0.17)	.033	b = 0.31 (0.22; 0.41)	< .001	b = 0.09 (0.01; 0.17)	.028
Mean CAL (ref. < 3 mm)*‖	≥ 3 mm	PR = 1.23 (1.14; 1.32)	< .001	PR = 1.25 (1.17; 1.33)	< .001	PR = 1.26 (1.17; 1.35)	< .001	PR = 1.07 (1.01; 1.13)	.029	PR = 1.26 (1.16; 1.36)	< .001	PR = 1.07 (1.01; 1.13)	.033
Mean PD, mm†‖		b = 0.15 (0.12; 0.18)	< .001	b = 0.13 (0.10; 0.15)	< .001	b = 0.13 (0.10; 0.16)	< .001	b = 0.06 (0.04; 0.08)	< .001	b = 0.11 (0.09; 0.14)	< .001	b = 0.06 (0.04; 0.08)	< .001
BOP (% sites)‡‖		b = 0.01 (−0.16; 0.19)	.864	b = 0.05 (−0.09; 0.20)	.464	b = −0.05 (−0.23; 0.12)	.562	b = −0.04 (−0.19; 0.11)	.627	b = −0.09 (−0.26; 0.09)	.342	b = −0.03 (−0.19; 0.12)	.662
Number of teeth (ref. ≥ 20)*#	< 20	PR = 2.11 (1.74; 2.56)	< .001	PR = 1.29 (0.97; 1.72)	.080	PR = 2.15 (1.77; 2.63)	< .001	PR = 1.29 (0.99; 1.68)	.057	PR = 2.04 (1.66; 2.51)	< .001	PR = 1.29 (1.00; 1.68)	.054

For each combination of exposure and oral health-related dependent variable, 3 separate models were calculated. The estimates refer to the exposure = smoking status (former smokers; current smokers vs never smoked [reference]). The unweighted dataset includes study participants with valid information on smoking status, age, gender, education, frequency of dental visits, frequency of tooth brushing, and frequency of interdental cleaning; two gender-diverse individuals were excluded from the association analyses.
b, regression coefficient; BOP, bleeding on probing; CAL, clinical attachment level; CI, confidence interval; OHRQoL, oral health-related quality of life; PD, probing depth; PR, prevalence ratio.
*Model specification: generalized linear model with mixed effects, family (Poisson), link function (logarithm).
†Model specification: generalized linear model with mixed effects, family (Gamma), link function (logarithm).
‡Model specification: fractional probit regression.
§Participants without gingival recession were excluded, feature not recorded in the age group of 20-year-olds.
‖Partial-mouth protocol: index teeth with 3 measurement sites.
#Only for the age group of 65- to 74-year-olds.
**Gender, age, education.
††Frequency of tooth brushing, frequency of interdental cleaning, frequency of dental visits.

istics and oral health behavior. The proportion of daily smokers was 16.2%. About one-quarter of the participants reported having quit smoking, while nearly 60% indicated they had never smoked. Women were significantly more likely than men to report never having smoked, whereas the proportion of daily smokers was notably higher among men. The group of daily smokers had a mean age of 45 years, similar to that of never smokers. The mean age of former smokers was significantly higher, at 55 years. Regarding education status, approximately one-third of former and never smokers belonged to the high education group, compared to only about one-sixth of daily smokers. In terms of oral health behavior, the proportion of individuals brushing their teeth twice a day, cleaning interdental spaces daily, and visiting a dental practitioner at least once a year was similar among former and never smokers but noticeably higher than among daily smokers.

An examination of smoking behavior revealed that daily smokers reported smoking for an average of 29 years, with a mean of 13 cigarettes per day. Among former smokers, the average duration of smoking exposure was approximately 18 years (results not shown).

Table 2 presents the oral health-related parameters descriptively by smoking status, while Table 3 shows the regression analysis results for these parameters. Both former and daily smokers more frequently reported moderate to very poor self-assessed oral health compared to never smokers. A similar trend was observed for impairments in oral health-related quality of life. The prevalence of a CAL of 3 mm or more, as well as the mean PD, was higher among both former and daily smokers compared to never smokers. These findings were corroborated in the regression analyses, where these associations remained

significant even after adjustment for sociodemographic characteristics and oral health behaviors. Compared to never smokers, daily smokers also had a higher prevalence of root caries and were more likely to have fewer than 20 teeth, even after adjustments for sociodemographic characteristics and oral health behaviors. No association was observed between smoking status and BOP, either for former or daily smokers. Regarding documented oral mucosal changes, daily smokers exhibited more lesions compared to the other subgroups (Table 2).

Discussion

The present analyses of the DMS • 6 data demonstrate that individuals who smoke daily have poorer outcomes in both self-assessed oral health parameters and dental-clinical parameters compared to those who have never smoked. These associations remained significant even after adjusting for sociodemographic characteristics and oral health behaviors. This trend is also largely observed among former smokers when compared to never smokers.

International studies support the association between smoking and oral health.[7,8,26-30] However, for a more direct comparison with the findings of the DMS • 6, other nationwide surveys conducted in Germany may be more suitable. The RKI in Berlin collects survey data on smoking behavior and self-reported oral health, among other things, within its nationwide health monitoring, including several waves of the GEDA study.[31-34] According to GEDA 2019/2020-EHIS, individuals reporting moderate to very poor self-assessed oral health were more likely to report daily smoking than those who assessed their oral health as very good or good.[31,34] Additionally, the same dataset revealed that individuals experiencing difficulties with chewing and biting were more likely to report daily smoking compared to those without such impairments.[32,33] Data from GEDA 2023 further showed that individuals who smoke are less likely to attend regular dental check-ups than non-smokers.[34] Moreover, the Survey of Health in Pomerania (SHIP) has explored the relationship between smoking and oral health,[35] demonstrating an association between tooth loss and smoking. Furthermore, a clear dose–response relationship has been established between smoking behavior and the severity of periodontal disease, including attachment loss and tooth loss.[36]

Conclusion

Given the strong impact that smoking has on oral health, comprehensive measures to curb smoking are essential.[7] Evidence-based behavioral and structural preventive measures exist to reduce tobacco use in the population and to increase smoking cessation.[37] These measures include regular increases in tobacco taxes, comprehensive bans on tobacco advertising, promotion, and sponsorship, warnings about the dangers of tobacco use, protection from passive smoking, and support for smoking cessation. Despite successes in tobacco prevention, there is still room for improvement in Germany in implementing internationally recommended measures, as reflected in the European Tobacco Control Scale for 2021, which compares the efforts of 37 countries regarding effective tobacco prevention and control.[38] Germany ranks second to last in this comparison.

However, studies indicate that dental offices can contribute to tobacco prevention and cessation efforts.[7] The present results show that a large proportion of the smoking population visits a dental practitioner at least once a year (79.8%, Table 1), presenting an opportunity for brief counseling on the risks of smoking and the benefits of smoking cessation for both oral and general health. There are various approaches to structuring such brief counseling, as outlined in the S3 guideline "Smoking and tobacco addiction: screening, diagnosis, and treatment."[39] Cochrane analyses show that brief counseling by physicians and smoking cessation interventions offered by dental practitioners can help smokers to quit more effectively.[40,41]

Therefore, success in improving oral health and reducing smoking requires a policy mix that involves diverse stakeholders and combines both structural and behavioral preventive measures.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. LK is a member of the DMS • 6 scientific advisory board and the author

of the manuscript. AS is a co-author of the manuscript. KH is a member of the DMS • 6 scientific advisory board, responsible for developing the clinical examinations, and a co-author of the manuscript. NFB is the former deputy study director, responsible for the social science study design, and a co-author of the manuscript. VP is a scientific advisor for the DMS • 6, jointly responsible for the statistical analyses, and a co-author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript.

References

1. Zeiher J, Finger JD, Kuntz B, Hoebel J, Lampert T, Starker A. Zeitliche Trends beim Rauchverhalten Erwachsener in Deutschland: Ergebnisse sieben bundesweiter Gesundheitssurveys 1991–2015. Bundesgesundheitsbl 2018;61:1365–1376.

2. Hoebel J, Kuntz B, Kroll LE, et al. Trends in absolute and relative educational inequalities in adult smoking since the early 2000s: the case of Germany. Nicotine Tob Res 2018;20:295–302.

3. Starker A, Schienkiewitz A, Damerow S, Kuhnert R. Verbreitung von Adipositas und Rauchen bei Erwachsenen in Deutschland – Entwicklung von 2003 bis 2023. J Health Monit 2025;10:e12990.

4. Mons U, Gredner T, Behrens G, Stock C, Brenner H. cancers due to smoking and high alcohol consumption. Dtsch Ärztebl Int 2018;115(35–36):571–577.

5. Institute for Health Metrics and Evaluation (IHME). GBD Results 2021. https://vizhub.healthdata.org/gbd-results/. Accessed 28 January 2025.

6. U.S. Department of Health and Human Services. The Health Consequences of Smoking – 50 Years of Progress: A Report of the Surgeon General. Atlanta: Centers for Disease Control and Prevention (US), 2014.

7. Winn DM. Tobacco use and oral disease. J Dent Educ 2001;65:306–312.

8. Ford PJ, Rich AM. Tobacco use and oral health. Addiction 2021;116:3531–3540.

9. Robert Koch Institut, Gesellschaft der epidemiologischen Krebsregister in Deutschland e.V. Krebs in Deutschland für 2019/2020. Berlin: Robert Koch Institut, 2023.

10. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in der Bundesrepublik Deutschland. Ergebnisse des nationalen IDZ-Survey 1989. Cologne: Deutscher Ärzte-Verl., 1991.

11. Micheelis W, Bauch J (eds). Mundgesundheitszustand und -verhalten in Ostdeutschland. Ergebnisse des IDZ-Ergänzungssurvey 1992. Cologne: Deutscher Ärzte-Verl., 1993.

12. Micheelis W, Reich E (eds). Dritte Deutsche Mundgesundheitsstudie (DMS III). Ergebnisse, Trends und Problemanalysen auf der Grundlage bevölkerungsrepräsentativer Stichproben in Deutschland 1997. Cologne: Deutscher Ärzte-Verl., 1999.

13. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl., 2006.

14. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

15. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.

16. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

17. Naik A, John MT, Kohli N, Self K, Flynn P. Validation of the English-language version of 5-item Oral Health Impact Profile. J Prosthodont Res 2016;60:85–91.

18. World Health Organization. Guide to epidemiology and diagnosis of oral mucosal diseases and conditions. Community Dent Oral Epidemiol 1980;8:1–26.

19. Ramanathan J, Leclercq MH, Mendis BR, Barmes DE. Gathering data on oral mucosal diseases: a new approach. World Health Forum 1995;16:299–304.

20. Roed-Petersen B, Renstrup G. A topographical classification of the oral mucosa suitable for electronic data processing. Its application to 560 leukoplakias. Acta Odontol Scand 1969;27:681–695.

21. Jordan AR, Meyer-Lückel H, Kuhr K, Sasunna D, Bekes K, Schiffner U. Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S30–S39.

22. Eickholz P, Holtfreter B, Kuhr K, Dannewitz B, Jordan AR, Kocher T. Prevalence of the periodontal status in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S40–S47.

23. Kocher T, Eickholz P, Kuhr K, et al. Trends in periodontal status: results from the German Oral Health Studies from 2005 to 2023. Quintessence Int 2025;56(Suppl): S48–S58.

24. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

25. Brauns H, Scherer S, Steinmann S. The CASMIN educational classification in international comparative research. In: Hoffmeyer-Zlotnik JH, Wolf C (eds). Advances in cross-national comparison. New York: Kluwer, 2003:221–244.

26. Csikar J, Kang J, Wyborn C, Dyer TA, Marshman Z, Godson J. The self-reported oral health status and dental attendance of smokers and non-smokers in England. PLoS ONE 2016;11:e0148700.

27. Liu Y. The relationship between lifestyle and self-reported oral health among American adults. Int Dent J 2014;64:46–51.

28. Duarte PM, Nogueira CFP, Silva SM, Pannuti CM, Schey KC, Miranda TS. Impact of smoking cessation on periodontal tissues. Int Dent J 2022;72:31–36.

29. Chung C-H, Yang Y-H, Wang T-Y, Shieh T-Y, Warnakulasuriya S. Oral precancerous disorders associated with areca quid chewing, smoking, and alcohol drinking in southern Taiwan. J Oral Pathol Med 2005;34:460–466.

30. Venkat A, Sathya Kumar M, Aravindhan R, Magesh KT, Sivachandran A. Analysis of oral leukoplakia and tobacco-related habits in population of Chengalpattu District: an institution-based retrospective study. Cureus 2022;14:e25936.

31. Krause L, Seeling S, Starker A. Selbstwahrgenommene Mundgesundheit und assoziierte Faktoren bei Erwachsenen in Deutschland. Ergebnisse aus GEDA 2019/2020-EHIS. Bundesgesundheitsbl 2021;64: 967–976.

32. Krause L, Seeling S, Schienkiewitz A, Fuchs J, Petrakakis P. Chewing ability and associated factors in older adults in Germany. Results from GEDA 2019/2020-EHIS. BMC Oral Health 2023;23:988.

33. Krause L, Seeling S, Petrakakis P. Beeinträchtigungen beim Kauen und Beißen – ein wichtiger Indikator für die Gesundheit im Alter? Zahnärztlicher Gesundheitsdienst 2024;24:9–11.

34. Krause L, Seeling S, Kuhnert R. Prävalenzen und Trends zur Inanspruchnahme zahnärztlicher Kontrolluntersuchungen bei Erwachsenen in Deutschland — Ergebnisse der GEDA-Studien zwischen 2009 und 2023. Dtsch Zahnärztl Z 2024;79:310–323.

35. Biffar R, Kocher T. Survey of health in Pomerania (SHIP) - Untersuchungen zur Mundgesundheit in einer multidisziplinären bevölkerungsrepräsentativen Studie. Forum Public Health 2005;13:17–19.

36. Meisel P, Heins G, Carlsson LE, et al. Impact of genetic polymorphisms on the smoking-related risk of periodontal disease: the population-based study SHIP. Tob Induc Dis 2003;1:197.

37. World Health Organization. WHO framework convention on tobacco control. Updated report. Geneva: World Health Organization, 2005.

38. Joossens L, Olefir L, Feliu A, Fernandez E. The tobacco control scale 2021 in Europe. Brussels: Smoke Free Partnership, Catalan Institute of Oncology, 2022.

39. Batra A, Kiefer F, Andreas S, et al. S3 Guideline "Smoking and Tobacco Dependence: Screening, Diagnosis, and Treatment" – Short Version. Eur Addict Res 2022;28:382–400.

40. Stead LF, Buitrago D, Preciado N, Sanchez G, Hartmann-Boyce J, Lancaster T. Physician advice for smoking cessation. Cochrane Database Syst Rev 2013;5: CD000165.

41. Holliday R, Hong B, McColl E, Livingstone-Banks J, Preshaw PM. Interventions for tobacco cessation delivered by dental professionals. Cochrane Database Syst Rev 2021;2:CD005084.

Laura Krause

Laura Krause Research Assistant, Department of Epidemiology and Health Monitoring, Robert Koch Institute, Berlin, Germany

Anne Starker Senior Researcher, Department of Epidemiology and Health Monitoring, Robert Koch Institute, Berlin, Germany

Katrin Hertrampf Professor for Prevention and Care in Dentistry, Clinic of Oral and Maxillofacial Surgery, University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Germany

Nicolas Frenzel Baudisch Senior Researcher, infas Institute for Applied Social Science, Bonn, Germany; until 2023: Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Vinay Pitchika Research Associate, Department of Conservative Dentistry and Periodontology, LMU Hospital, Munich, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Cardiovascular diseases and oral health: results of the 6th German Oral Health Study (DMS • 6)

A. Rainer Jordan, Prof Dr med dent, MSc/Kathrin Kuhr, Dr rer medic/Dominic Sasunna/
Wolfgang Rathmann, Prof Dr med, MSPH

Objectives: Epidemiologic studies have indicated a correlation between dental and cardiovascular diseases, which remains insufficiently explored. Therefore, this study aimed to compare the prevalence of common dental diseases in younger seniors (65- to 74-year-olds) with and without cardiovascular diseases. **Method and materials:** Participants with available self-reported data on cardiovascular diseases were selected from the cohort of the population-representative 6th German Oral Health Study (DMS • 6), in which caries, periodontitis, and tooth loss were recorded in a standardized manner. The prevalence of oral diseases was compared between participants with and without cardiovascular diseases. **Results:** Compared with participants without cardiovascular diseases, those with cardiovascular diseases had an average of 2.1 fewer teeth, were more frequently edentulous, and were more likely to have advanced periodontal disease (stage IV). In contrast, participants without cardiovascular disease had more fillings (mean + 1.7 teeth) than those with cardiovascular disease. **Conclusion:** The main cause of increased tooth loss — caries or periodontal disease — could not be clarified from the available data. In this study, the prevalence of tooth loss with oral-function limitation was higher in younger seniors with cardiovascular disease.
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Keywords: cardiovascular diseases, cross-sectional studies, dental care, dental caries, dentists, DMS 6, epidemiology, oral health, risk factors

Cardiovascular diseases are mainly associated with periodontal diseases,[1] and evidence regarding their correlation with other oral diseases is limited. The Fifth German Oral Health Study (DMS V)[2] was the first study in Germany to examine the oral health status of younger seniors (65- to 74-year-olds) with severe disabilities (≥ 50%). The study revealed a higher incidence of caries in the target group than in the control group. However, differences in periodontal health were less distinct. On average, younger seniors with severe disability had 3.8 fewer functional teeth, and complete edentulism was almost twice as frequent as in the entire age group (22.7% vs 12.4%). However, the diseases underlying severe disabilities were diverse. Thus, the analysis could not identify associations with socially significant chronic diseases.

Therefore, the 6th German Oral Health Study (DMS • 6) aimed to examine the correlation between epidemiologically significant dental diseases (caries, periodontitis, and tooth loss) and cardiovascular diseases in younger seniors (65- to 74-year-olds).

Method and materials

The general methodology of the study is presented in separate articles.[3,4] The DMS • 6 was approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). The study was registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

For the data analysis, participants aged 65 to 74 years with available self-reported data on cardiovascular diseases were

selected from those who met the inclusion criteria for the DMS • 6 analysis set. In total, data from 791 younger seniors were included in the analysis; six individuals were excluded because of missing information.

Variables

Cardiovascular disease

Medically diagnosed cardiovascular diseases (self-reported) were recorded as part of the social science survey. Cardiovascular disease was defined as the presence of at least one of the following diagnoses:

- myocardial infarction
- coronary heart disease or angina pectoris
- cardiac insufficiency
- cardiac arrhythmias
- intermittent claudication or peripheral vascular disease
- stroke.

Dental endpoints

The following variables recorded during the clinical examination were selected for the analysis of the research questions:

- caries experience (decayed, missing, filled teeth [DMFT]) and prevalence of root caries[5]
- number of filled or sound teeth (FST index), tooth loss, and edentulism[5]
- degree of restoration of coronal caries (%)[5]
- plaque accumulation (modified Marginal Plaque Index [mMPI])[6]
- gingivitis and periodontal findings (bleeding on probing [BOP]; European Federation of Periodontology/American Academy of Periodontology [EFP/AAP] classification).[7]

Social characteristics

Data regarding the following general social characteristics were collected:

- sociodemographic factors (eg, age, gender, and education status)
- medical history and physiological characteristics (eg, body mass index and diabetes mellitus)
- smoking status
- self-assessment of oral health status
- oral hygiene behavior (eg, tooth brushing frequency and interdental cleaning frequency)
- dental service utilization (eg, dental visits and professional tooth cleaning).

Statistical analysis

Participants were divided into two groups based on the presence of cardiovascular disease. Regarding the epidemiologic description of oral diseases, prevalence rates or means were calculated with corresponding 95% confidence intervals (CIs). A weighted dataset was used to compensate for differing probabilities in the selection of study participants and differences in terms of gender, age, and region compared with the overall population in Germany. Descriptive analyses of sociodemographic variables used to characterize the study participants were not weighted. Numbers (n) are provided without weighting. Detailed information on data handling and statistical methods is described previously.[8]

Results

The participants' characteristics are presented in Table 1. Overall, 27.6% of the participants had self-reported cardiovascular disease (Table 2).

Systematic differences in social and general medical variables were observed between the groups with and without cardiovascular diseases (Table 1). Participants with cardiovascular diseases were slightly older and more frequently male. Moreover, the average education status was lower than that of participants without cardiovascular diseases. In addition, the mean body mass index was different between the groups; more participants with cardiovascular diseases were obese (body mass index ≥ 30 kg/m^2). Other social characteristics were not significantly different between the groups (Table 1).

General dental health profile

Younger seniors with cardiovascular diseases had a lower mean number of teeth (−2.1 teeth) and were edentulous more often than participants without cardiovascular diseases (7.4% vs 4.2%). No differences were observed in plaque accumulation (mMPI) or gingival bleeding (BOP) (Table 3).

Periodontal health profile

Comparative analyses of periodontal parameters, such as the mean periodontal probing depth and clinical attachment level, revealed no significant differences between the two groups (Table 3). However, the prevalence of severe periodontal disease (stage IV) tended to be higher in participants with cardiovascular diseases than in those without (29.0% vs 25.5%; Table 4).

Table 1 Baseline characteristics of study participants for younger seniors (65- to 74-year-olds) by cardiovascular disease

Variable		Cardiovascular disease	
		Yes	No
No. of participants (n)		216	575
Age, years		70.4 ± 2.6	69.5 ± 2.8
Gender	Male	123 (56.9%)	248 (43.1%)
	Female	93 (43.1%)	327 (56.9%)
Education group	Low	51 (24.9%)	107 (19.5%)
	Medium	98 (47.8%)	269 (48.9%)
	High	56 (27.3%)	174 (31.6%)
Monthly net equivalent income, Euro		1,901 ± 924	2,031 ± 1,081
Migration history	People with migration history	34 (16.7%)	71 (12.9%)
	People without migration history	170 (83.3%)	478 (87.1%)
Smoking status	Never smoked	92 (42.6%)	288 (50.1%)
	Former smoker	95 (44.0%)	203 (35.3%)
	Current smoker	29 (13.4%)	84 (14.6%)
Body mass index, kg/m^2		28.5 ± 5.0	26.9 ± 4.9
	< 25	46 (22.7%)	196 (36.1%)
	25 – < 30	88 (43.3%)	223 (41.1%)
	≥ 30	69 (34.0%)	124 (22.8%)
Diabetes mellitus (self-reported)	No or gestational diabetes	174 (80.6%)	490 (85.5%)
	Type 1 diabetes	0 (0.0%)	1 (0.2%)
	Type 2 diabetes	42 (19.4%)	82 (14.3%)
Self-assessment of oral health status	Very good / good	129 (60.0%)	375 (65.2%)
	Moderate / poor / very poor	86 (40.0%)	200 (34.8%)
Tooth brushing (frequency)	≥ 2 times daily	162 (82.2%)	456 (83.8%)
	< 2 times daily	35 (17.8%)	88 (16.2%)
Interdental cleaning (frequency)	≥ once daily	63 (32.0%)	219 (40.3%)
	< once daily	134 (68.0%)	325 (59.7%)
Dental visits (frequency)	≥ once a year	182 (85.4%)	506 (88.5%)
	< once a year	31 (14.6%)	66 (11.5%)
Dental service utilization	Complaint-oriented	34 (15.7%)	69 (12.0%)
	Control-oriented	182 (84.3%)	505 (88.0%)
Professional tooth cleaning (utilization)	Yes	153 (72.2%)	465 (81.0%)
	No	58 (27.4%)	107 (18.6%)
	Don't know	1 (0.5%)	2 (0.3%)
Professional tooth cleaning (frequency)	Never	58 (28.7%)	107 (19.5%)
	< once a year	36 (17.8%)	134 (24.4%)
	≥ once a year	108 (53.5%)	308 (56.1%)
Lifetime periodontal treatment (utilization)	Yes	71 (33.3%)	183 (31.8%)
	No	133 (62.4%)	370 (64.3%)
	Don't know	9 (4.2%)	22 (3.8%)

Data are presented as numbers (percentages) or mean ± standard deviation based on unweighted data. Cardiovascular diseases (≥ 1; self-reports): myocardial infarction, angina pectoris, cardiac insufficiency, cardiac arrhythmias, intermittent claudication, stroke.

Caries and oral health care related health profile

Caries experience (DMFT) was not significantly different between the two groups. However, stratification of the composite index of DMFT yielded differences. Participants without cardiovascular disease had more fillings (+ 1.7 teeth) than those with cardiovascular disease. The proportion of untreated carious teeth was comparable between the groups. Owing to the higher proportion of fillings among participants without cardiovascular diseases, a difference was observed in the FST index between the groups with and without cardiovascular disease (17.3 teeth vs 19.4 teeth). Additionally, there was a statistical difference in the prevalence of root caries between the groups with and without cardiovascular disease (52.5 % vs 61.2 %). These results align with the teeth-at-risk concept, which suggests that increased tooth retention increases the risk of root caries and periodontitis (Table 3).

Oral health status and oral hygiene behavior

Overall, participants with cardiovascular disease assessed their own oral health status as less favorable. Annual dental visits were less frequent and more complaint-oriented in this group. Moreover, interdental and professional tooth cleaning were reported less frequently. However, participants with cardiovascular disease were more likely to have undergone lifetime periodontal treatment (Table 1).

Discussion

A comparative evaluation of key dental health parameters between younger seniors (65- to 74-year-olds) with and without cardiovascular diseases showed that individuals with cardiovascular disease had approximately two fewer teeth, and the number of healthy functional teeth was smaller. Moreover, younger seniors with cardiovascular disease more frequently tended to be edentulous and exhibited a higher prevalence of severe periodontal disease (stage IV).

A previous study reported a higher risk of cardiovascular disease in patients with periodontitis. Moreover, the risk of the first coronary event was higher in individuals with severe periodontitis than in those with mild or no periodontitis. Furthermore, correlations between periodontal diseases and cerebrovascular disease and stroke were observed; however, these associations were not observed in seniors (age > 65 years).[9] In addition, a meta-analysis reported a correlation between periodontitis and arteriosclerotic diseases,[10] and a national health survey in Taiwan reported an association between atrial fibrillation and periodontitis.[11]

Table 2 Prevalence of cardiovascular diseases among younger seniors (65- to 74-year-olds)

Variable	65- to 74-year-olds
No. of participants (n)	791
Cardiovascular disease (prevalence)	27.6% (24.6; 30.8)
Myocardial infarction	6.2% (4.6; 7.9)
Angina pectoris	6.7% (5.1; 8.6)
Cardiac insufficiency	6.7% (5.1; 8.6)
Cardiac arrhythmias	14.3% (11.9; 16.8)
Intermittent claudication	4.4% (3.1; 6.0)
Stroke	4.2% (3.0; 5.8)

Data are presented as unweighted numbers (n) and weighted percentages (with 95% confidence intervals).

Nonetheless, transdisciplinary caries research links cardiovascular diseases to dietary habits and follows the "common risk factor approach."[5] The focus is on low-molecular-weight carbohydrate intake and diabetes and its relationship with overweight or obesity.[12]

Inflammation may be a possible causal explanation for the association between dental and cardiovascular diseases.[13] Insufficient oral hygiene is the main cause of periodontitis and is associated with systemic inflammatory reactions and elevated concentrations of C-reactive protein and other inflammatory biomarkers.[14] Several studies have reported a correlation between tooth brushing and cardiovascular diseases.[14-16] In the DMS • 6, extensive video recordings were made; however, analyses of the videos are not expected to be available until 2026.

Existing evidence suggests that among dental diseases, periodontal diseases are mainly correlated with cardiovascular diseases.[9] In the present study, the prevalence of severe periodontal disease tended to be higher in the group with cardiovascular diseases; however, other periodontal parameters were not significantly different between the groups. Therefore, the results of previous studies could not be confirmed. This could be attributed to the differing definitions and survey methods used for cardiovascular diseases. Nonetheless, regarding the final endpoint of periodontal disease, that is tooth loss, the results were clearly in line with those of previous studies.

Tooth loss appears to be a definitive indicator of poor oral health among younger seniors with cardiovascular diseases. Tooth loss is associated with cardiac health, periodontal markers, and oral function. The extent to which the two main oral diseases, caries and periodontitis, and particularly which of the two, seem to be the primary cause increased tooth loss, could

Table 3 Epidemiologic estimates and self-reported treatment of oral diseases in younger seniors (65- to 74-year-olds) by cardiovascular disease

	Cardiovascular disease	
Variable	Yes	No
No. of teeth (n)	17.7 (16.5; 18.9)	19.8 (19.2; 20.5)
Edentulism (prevalence)	7.4% (4.4; 11.4)	4.2% (2.8; 6.1)
DMFT	17.9 (17.1; 18.8)	17.6 (17.2; 18.0)
DT	0.4 (0.3; 0.5)	0.4 (0.3; 0.5)
MT	10.1 (8.9; 11.4)	8.0 (7.4; 8.7)
FT	7.4 (6.7; 8.2)	9.1 (8.7; 9.6)
FST	17.3 (16.1; 18.5)	19.4 (18.7; 20.0)
ST	9.9 (9.1; 10.7)	10.2 (9.8; 10.6)
Degree of restoration of coronal caries (%)	90.7 (87.3; 94.0)	94.2 (92.8; 95.7)
Root caries (prevalence)	52.5% (45.7; 58.9)	61.2% (57.3; 65.2)
mMPI (% segments with plaque)	45.6 (41.3; 49.9)	43.6 (41.3; 45.0)
BOP (% sites)	21.1 (17.8; 24.4)	20.0 (18.2; 21.7)
Mean PD, mm	2.7 (2.6; 2.8)	2.6 (2.5; 2.7)
Mean CAL, mm	2.5 (2.3; 2.8)	2.3 (2.2; 2.5)
CAL ≥ 3 mm (prevalence)	97.6% (94.8; 99.4)	95.0% (92.8; 96.6)

Data are presented as weighted percentages or weighted means (with 95% confidence intervals).
BOP, bleeding on probing; CAL, clinical attachment level; DMFT, decayed, missing, filled teeth; DT, decayed teeth; FST, filled or sound teeth; FT, filled teeth; mMPI, modified Marginal Plaque Index; MT, missing teeth; PD, probing depth; ST, sound teeth.
Cardiovascular diseases (≥ 1; self-reports): myocardial infarction, angina pectoris, cardiac insufficiency, cardiac arrhythmias, intermittent claudication, stroke.

Table 4 Categorization according to the 2018 EFP/AAP periodontitis classification in younger seniors (65- to 74-year-olds) by cardiovascular disease

		Cardiovascular disease	
Variable		Yes	No
No. of participants (n)		189	577
Periodontitis cases	All stages	78.0% (58.7; 100.0)	87.6% (74.9; 100.0)
	Stage I	5.9% (3.1; 9.8)	9.2% (7.1; 12.0)
	Stage II	23.1% (17.7; 29.7)	24.6% (21.2; 28.3)
	Stage III	20.0% (14.9; 26.2)	28.1% (24.6; 32.0)
	Stage IV	29.0% (23.0; 35.9)	25.5% (22.0; 29.2)
Edentulous		8.5% (5.1; 13.1)	4.3% (2.9; 6.2)
Non-classified*		13.5% (9.4; 19.2)	8.1% (6.0; 10.6)

Data are presented as unweighted numbers (n) and weighted percentages (with 95% confidence intervals) for edentate and dentate participants with complete periodontal findings.
*Periodontitis case definition not applicable.
EFP/AAP, European Federation of Periodontology/American Academy of Periodontology.
Cardiovascular diseases (≥1; self-disclosures): myocardial infarction, angina pectoris, cardiac insufficiency, cardiac arrhythmias, intermittent claudication, stroke.

not be determined from this cross-sectional analysis. However, in individuals aged > 40 years tooth loss is mainly caused by periodontal disease.[17] Thus, the oral health differences in this study could be attributed mainly to periodontal diseases.

Future longitudinal studies should investigate this using long-term study cycles (life-span studies) because tooth loss is, if not the result of trauma, the end stage of long-term oral diseases with various etiologies. The longitudinal component of

DMS • 6, with a re-survey and re-analysis of the study participants from DMS V of 2014, aims to investigate this topic.

One strength of this study is that the examined participants were surveyed as part of a population-representative study. Therefore, selection bias owing to regional differences or other distorting effects was less likely. The results from other population studies that reported the prevalence of cardiovascular diseases are consistent with the present findings.[18-21] The results largely correspond with current data (prevalence of cardiovascular diseases in younger seniors, 27.6%). A limitation of the present study is that because the information regarding underlying diseases was self-reported provided by the participants, it does not represent a reliable medical diagnosis. In contrast, dental diagnoses as part of the DMS • 6 were made exclusively by the dental practitioners conducting the study. Nonetheless, cross-sectional epidemiologic studies do not allow for conclusive evaluations, but can merely identify statistical associations. Therefore, this evaluation has hypothesis-generating characteristics.

Conclusion

Despite advances in dental care and efforts to collaborate with other disciplines, awareness regarding the correlation between oral health and cardiovascular diseases is lacking, especially among at-risk groups susceptible to systemic inflammation, such as individuals with diabetes or hypertension.[22] Considering the increasing insights into oral health and its impact on cardiovascular diseases, greater awareness of this relationship among general practitioners and cardiologists is urgently required to improve education and dental referrals to prevent cardiovascular diseases.[23]

Disclosure

ARJ, KK, and DS are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and the author of the manuscript. DS is jointly responsible for the statistical data processing and analysis. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. WR is a member of the extended scientific advisory board of the DMS • 6 and a co-author of the manuscript.

References

1. Sanz M, Del Marco Castillo A, Jepsen S, et al. Periodontitis and cardiovascular diseases: Consensus report. J Clin Periodontol 2020;47:268–288.
2. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.
3. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.
4. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.
5. Jordan AR, Meyer-Lückel H, Kuhr K, Sasunna D, Bekes K, Schiffner U. Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S30–S39.
6. Deinzer R, Jordan AR, Kuhr K, Margraf-Stiksrud J. Oral hygiene behavior and toothbrushing skills: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S82–S87.
7. Eickholz P, Holtfreter B, Kuhr K, Dannewitz B, Jordan AR, Kocher T. Prevalence of the periodontal status in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S40–S47.
8. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.
9. Dietrich T, Sharma P, Walter C, Weston P, Beck J. The epidemiological evidence behind the association between periodontitis and incident atherosclerotic cardiovascular disease. J Periodontol 2013;84(4 Suppl): S70–S84.
10. Yang S, Zhao LS, Cai C, Shi Q, Wen N, Xu J. Association between periodontitis and peripheral artery disease: a systematic review and meta-analysis. BMC Cardiovasc Disord 2018;18:141.
11. Chen D-Y, Lin C-H, Chen Y-M, Chen H-H. Risk of atrial fibrillation or flutter associated with periodontitis: a nationwide, population-based, cohort study. PLoS One 2016; 11:e0165601.
12. Huysmans MC, Fontana M, Lussi A, et al. European Organisation for Caries Research and the European Federation of Conservative Dentistry Consensus Report on Clinical Recommendations for Caries Diagnosis: Paper III - Caries Diagnosis at the Individual Level. Caries Res 2024;58:521–532.
13. Hopkins S, Gajagowni S, Qadeer Y, et al. Oral health and cardiovascular disease. Am J Med 2024;137:304–307.

14. Oliveira C de, Watt R, Hamer M. Toothbrushing, inflammation, and risk of cardiovascular disease: results from Scottish Health Survey. Br Med J 2010;340:c2451.

15. Isomura ET, Suna S, Kurakami H, et al. Not brushing teeth at night may increase the risk of cardiovascular disease. Sci Rep 2023;13:10467.

16. Moon M-G, Kang S-H, Kim S-H, et al. Association between toothbrushing and cardiovascular risk factors: a cross-sectional study using Korean National Health and Nutrition Examination Survey 2015–2017. BMC Oral Health 2024;24:4.

17. Micheelis W, Jordan AR. Zeitliche Dynamik der Zahnverluste in Deutschland. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016:591–594.

18. Busch MA, Kuhnert R. 12-Month prevalence of coronary heart disease in Germany. J Health Monit 2017;2:58–63.

19. Störk S, Handrock R, Jacob J, et al. Epidemiology of heart failure in Germany: a retrospective database study. Clin Res Cardiol 2017;106:913–922.

20. Schnabel RB, Wilde S, Wild PS, Munzel T, Blankenberg S. Atrial fibrillation: its prevalence and risk factor profile in the German general population. Dtsch Arztebl Int 2012; 109:293–299.

21. Busch MA, Schienkiewitz A, Nowossadeck E, Gößwald A. Prävalenz des Schlaganfalls bei Erwachsenen im Alter von 40 bis 79 Jahren in Deutschland: Ergebnisse der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1). Bundesgesundheitsbl 2013;56:656–660.

22. Usmani W, Courten M de, Hanna F. Can oral health care be a gateway to improve cardiovascular disease? A scoping review. Front Oral Health 2024;5:1364765.

23. Gianos E, Jackson EA, Tejpal A, et al. Oral health and atherosclerotic cardiovascular disease: a review. Am J Prev Cardiol 2021; 7:100179.

A. Rainer Jordan

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Dominic Sasunna Data manager, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Wolfgang Rathmann Professor, Institute for Biometrics and Epidemiology, German Diabetes Center (DDZ), Leibniz Center for Diabetes Research, Heinrich Heine University Düsseldorf, Düsseldorf, Germany

Correspondence: Institut der Deutschen Zahnärtze, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Oral health in the elderly: results of the 6th German Oral Health Study (DMS • 6)

Stefanie Samietz*, Priv-Doz Dr med dent, MPH, MSc/Bernd Wöstmann*, Prof Dr med dent/Kathrin Kuhr, Dr rer medic/A. Rainer Jordan, Prof Dr med dent, MSc/Helmut Stark#, Prof Dr med dent/Ina Nitschke#, Prof Dr med dent, MPH

Objectives: Oral health plays a central role in overall well-being, including in the elderly. The demographic transition and its effects are resulting in a higher proportion of older people, both with and without care requirements. This paper provides an overview of the dental situation of the elderly from the 6th German Oral Health Study (DMS • 6). **Method and materials:** DMS • 6 is a population-representative oral epidemiologic study that surveys oral health in Germany. Data from 797 younger seniors aged 65 to 74 were collected by calibrated examiners. The methodology remains largely consistent with that of the previous studies. **Results:** Among the younger seniors (65- to 74-year-olds), edentulism has more than halved to 5.0% compared to the Fifth German Oral Health Study (DMS V) (12.4% in 2014). The mean number of missing teeth (8.6) decreased further, compared to DMS IV (14.1) and DMS V (11.1). At 18.8 teeth, the FST Index (number of filled or sound teeth) has shown improvement compared to the previous studies (DMS IV, 13.6; DMS V, 16.4). The root caries (59.1%) increased compared to DMS IV (28.0%). Caries experience (decayed, missing, filled teeth [DMFT]: 17.6), in contrast, hardly changed from DMS V (17.7). Half of 65- to 74-year-olds were diagnosed with moderate periodontitis (49.4%) and almost a third (30.4%) with severe periodontitis. In younger seniors with care requirements, therapeutic capability was greatly reduced for almost half (47.4%) and oral hygiene ability for one fifth (18.5%). **Conclusion:** The prevalence of tooth loss and edentulism among younger seniors in Germany continues to decline. Due to further morbidity compression, the challenges of dental treatment lie in the continuous treatment of younger seniors to prepare them for older stages of life. *(Quintessence Int 2025;56 (Suppl):S112–S119; doi: 10.3290/j.qi.b5982021)*

Keywords: care needs, dental care, dental care for persons with disabilities, dental caries, dentists, DMS 6, epidemiology, geriatric dentistry, oral health

The prevalence of edentulism and of tooth loss has been decreasing, resulting in more teeth being retained into old age.[1-3] The proportion of edentulous 65- to 74-year-old study participants in DMS V (2014, 12.4%) was halved compared to 1997 (DMS III, 24.8%).[1,4] Oral health plays a central role in overall well-being, especially in the elderly. Age-related diseases and the risk of severe systemic diseases such as diabetes mellitus or cardiovascular diseases can be exacerbated by periodontitis and peri-implantitis, which occur frequently in advanced age.

As a result of the demographic transition, the proportion of over-65-year-olds in the general population is increasing in the Global North. An aging population leads to a higher proportion of people with care needs. In 2021, 84% of the 5 million people with care requirements in Germany received care at home by relatives and mobile care services. Projections of demographic trends indicate an increase in care needs to 5.6 million people by 2035 and to 6.8 million people by 2055.[5] Among those in need of care, 79% were aged 65 and older, and one-third (33%) were at least 85 years old. The majority of these individuals were female (62%). The probability of needing care increases with older age. While only around 9% of 70- to 74-year-olds required care, the highest care rate was found for those aged 90 and older (82%).[1,6] The group of younger seniors also includes people with disabilities whose consequences must be addressed in their daily life. These disabilities vary widely and may have physical, mental, or psychological effects.

The present study aims to present the oral health of 65- to 74-year-old seniors in Germany, including those with care requirements and severe disabilities.

Method and materials

The general methodology of the study is presented in separate articles.[7,8] The 6th German Oral Health Study (DMS • 6) has been approved by the Institutional Review Board of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

For the data analysis, all study participants in the group of younger seniors (65- to-74-year-olds) were selected from those who met the inclusion criteria of the DMS • 6 analysis set. A total of 797 younger seniors were included in the analysis.

Measurement methods and variables

In DMS • 6, oral functional capacity[9] was investigated in seniors aged 65 to 74 according to three subject fields: therapeutic capability, oral hygiene ability, and self-responsibility. Therapeutic capability was assessed by the dental examiner. This included determining whether dental treatment of the study participants could be the same as for generally healthy and normally functional study participants or whether restrictions were necessary due to reduced functionality (eg, number and duration of treatment appointments, selection of the simpler treatment concept and of a simpler prosthesis). The financial situation of the study participants and their dental status had no effect on therapeutic capability. To assess oral hygiene ability, the ability to partake in an individual prophylactic dental treatment session was evaluated along with cognitive and motor skills required to implement and understand oral and prosthesis hygiene. Therapeutic capability and oral hygiene ability were classified into normal, slightly reduced, and greatly reduced. Self-responsibility was classified into normal, reduced, and none. This criterion describes whether study participants were capable of deciding to seek a dental practitioner for check-up or treatment and of organizing the appointment themselves.[9]

The care requirements were determined by asking about regular services provided by long-term care insurance or another benefits provider due to individual care requirements.

Persons with a degree of disability of less than 50% are defined as disabled (degree of disability < 50%). Study participants with a degree of disability of at least 50% (degree of disability ≥ 50%) are deemed severely disabled.

Table 1 Baseline characteristics of study participants for younger seniors (65- to 74-year-olds)

Variable		65- to 74-year-olds
No. of participants (n)		797
Age, years		69.8 ± 2.8
Gender	Female	422 (52.9%)
	Male	375 (47.1%)
Education group	Low	158 (20.9%)
	Medium	367 (48.6%)
	High	230 (30.5%)
Migration history	Yes	105 (13.9%)
	No	648 (86.1%)
Smoking status	Never smoked	380 (48.0%)
	Former smoker	299 (37.8%)
	Current smoker	113 (14.3%)
Body mass index, kg/m^2		27.4 ± 5.0
	< 25	242 (32.4%)
	25 – < 30	311 (41.7%)
	≥ 30	193 (25.9%)
Diabetes mellitus	Type 2 diabetes	124 (15.7%)
	Type 1 diabetes	1 (0.1%)
	No or gestational diabetes	664 (84.2%)
Officially recognized disability	Degree of disability < 50%	50 (6.8%)
	Severe disability (degree of disability ≥ 50%)	111 (15.1%)
	No	572 (78.0%)
Receipt of nursing care	Yes	26 (3.7%)
	No	677 (96.3%)
Level of care	Level of care 1	5 (0.7%)
	Level of care 2	14 (2.0%)
	Level of care 3	3 (0.4%)
	Level of care 4	3 (0.4%)
	Level of care 5	0 (0.0%)
Tooth brushing (frequency)	≥ 2 times daily	619 (83.4%)
	< 2 times daily	123 (16.6%)
Interdental cleaning (frequency)	≥ once daily	283 (38.1%)
	< once daily	459 (61.9%)
Dental visits (frequency)	≥ once a year	689 (87.7%)
	< once a year	97 (12.3%)
Dental service utilization	Complaint-oriented	103 (13.0%)
	Control-oriented	688 (87.0%)

Data are presented as numbers (percentages) or mean ± standard deviation based on unweighted data.

For the analysis of the research question, variables from the clinical examination were selected; for caries-related endpoints, further details are available in Jordan et al[10]; for periodontal endpoints in Eickholz et al[11] and Kocher et al[12]; and for prothesis endpoints in Wöstmann et al.[13]

Table 2 Oral functional capacity of younger seniors (65- to 74-year-olds)

Variable		Total	Gender		Severe disability		Care requirement	
			Male	Female	Yes	No	Yes	No
No. of participants (n)*		794	372	422	111	620	26	675
Resilience capacity level (%)	Normal	79.7 (76.8; 82.4)	79.8 (75.7; 83.7)	79.6 (75.6; 83.4)	76.5 (67.4; 83.6)	82.1 (78.9; 84.9)	27.0 (14.5; 46.8)	81.2 (78.1; 84.1)
	Slightly reduced	11.8 (9.7; 14.2)	9.8 (7.2; 13.2)	13.8 (10.6; 17.3)	11.2 (6.4; 18.5)	11.5 (9.2; 14.2)	20.4 (9.5; 38.9)	12.1 (9.8; 14.8)
	Greatly reduced	7.9 (6.2; 10.0)	9.3 (6.8; 12.6)	6.6 (4.5; 9.3)	10.9 (5.7; 17.4)	6.2 (4.5; 8.3)	48.2 (32.2; 67.8)	6.2 (4.6; 8.2)
	No resilience	0.6 (0.2; 1.2)	1.1 (0.4; 2.5)	0.0 (NA)	1.3 (0.1; 4.4)	0.2 (0.0; 0.8)	4.5 (0.4; 15.5)	0.5 (0.1; 1.2)
Therapeutic capability (%)	Normal	87.9 (85.5; 90.0)	89.0 (85.6; 91.9)	86.8 (83.3; 89.8)	82.4 (73.7; 88.4)	90.5 (87.9; 92.6)	30.0 (14.5; 46.8)	89.6 (87.2; 91.9)
	Slightly reduced	9.3 (7.3; 11.4)	7.1 (4.8; 9.9)	11.3 (8.5; 14.6)	10.5 (5.7; 17.4)	8.6 (6.6; 11.0)	22.6 (9.5; 38.9)	9.4 (7.3; 11.8)
	Greatly reduced	2.9 (1.9; 4.2)	3.9 (2.3; 6.2)	1.9 (0.9; 3.7)	7.1 (3.0; 12.6)	0.9 (0.4; 2.0)	47.4 (29.1; 64.5)	1.0 (0.5; 2.1)
	None	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)	0.0 (NA)
Oral hygiene ability (%)	Normal	88.0 (85.6; 90.1)	85.8 (82.2; 89.1)	90.1 (86.8; 92.6)	85.8 (78.1; 91.4)	89.7 (87.1; 91.9)	37.8 (23.0; 57.7)	89.8 (87.4; 92.0)
	Slightly reduced	9.7 (7.8; 11.9)	11.3 (8.3; 14.6)	8.3 (5.9; 11.3)	9.3 (5.0; 16.2)	9.0 (7.0; 11.5)	43.8 (26.0; 61.1)	8.7 (6.7; 10.9)
	Greatly reduced	1.9 (1.1; 3.0)	2.1 (1.0; 3.9)	1.6 (0.8; 3.3)	3.5 (1.3; 8.8)	1.3 (0.6; 2.4)	18.5 (7.2; 34.8)	1.1 (0.5; 2.1)
	None	0.4 (0.1; 1.0)	0.8 (0.2; 2.1)	0.0 (NA)	1.3 (0.1; 4.4)	0.0 (NA)	0.0 (NA)	0.5 (0.1; 1.2)
Self-responsibility (%)	Normal	92.9 (91.0; 94.6)	91.1 (88.0; 93.7)	94.7 (92.1; 96.5)	92.5 (86.1; 96.3)	94.4 (92.3; 96.0)	62.6 (45.8; 79.9)	94.3 (92.3; 95.8)
	Reduced	6.9 (5.3; 8.9)	8.6 (6.1; 11.7)	5.3 (3.5; 7.9)	7.5 (3.7; 13.9)	5.4 (3.9; 7.5)	32.9 (17.2; 50.5)	5.7 (4.2; 7.7)
	None	0.2 (0.0; 0.6)	0.3 (0.0; 1.2)	0.0 (NA)	0.0 (NA)	0.2 (0.0; 0.8)	4.5 (0.4; 15.5)	0.0 (NA)

*Study participants with valid information on oral functional capacity.
Data are presented as unweighted numbers (n) and weighted percentages (with 95% confidence intervals). NA, not applicable.

Statistical analysis

For the epidemiologic description of oral diseases, prevalences and means with associated 95% confidence intervals (CIs) were calculated. A weighted dataset was used for this purpose. The aim was to balance differing probabilities through the use of the weights when selecting the study participants and differences regarding gender, age, and region compared to the basic population in Germany. Results were presented for the whole seniors group as well as stratified by gender (male/female); the characteristic oral functional capacity was further stratified by severe disability (yes/no) and by care requirement (yes/no).

Descriptive analyses of social-scientific characteristics to profile the study participants were unweighted, and numbers (n) are provided without weighting. Detailed information on data handling and statistical methods is described previously.[14]

Results

In DMS • 6, 797 participants aged between 65 and 74, of whom 422 (52.9%) were women and 375 (47.1%) were men, were examined. Of these, 13.9% had a migration history. In total, 111 (15.1%) seniors were severely disabled, 50 (6.8%) were disabled, and 26 (3.7%) received nursing care. Furthermore, 87.0% of participants visited the dental practitioner for check-ups, while 13.0% did so for symptom treatment (Table 1).

Oral functional capacity

With regard to therapeutic capability, 87.9% of the participating younger seniors were able to be treated normally from a dental perspective, ie as generally medically healthy individuals without functional restrictions. Among the younger seniors with severe disabilities, this figure was 82.4%, while among participants with care needs, it was 30.0%. A large reduction in therapeutic capability was observed in participants aged 65 to 74 with care needs, at 47.4%. The vast majority of the younger seniors could maintain oral hygiene completely independently (88.0%) or with slightly reduced ability (9.7%) (Table 2). In contrast, 18.5% of participants requiring care were classified as having a greatly reduced oral hygiene ability. Further, 92.9% of the younger seniors demonstrated self-responsibility, ie they

could independently handle decisions on and the organization of dental appointments. However, of the younger seniors with a care requirement, 32.9% had greatly reduced self-responsibility, while 4.5% lacked self-responsibility.

Of 794 younger seniors with valid information on oral functional capacity, 79.7% had a normal resilience capacity level from a dental perspective, ie in principle all dental treatments were possible due to the overall good condition of the study participants (Table 2). Approximately 11.8% of participating younger seniors had slightly reduced resilience capacity, ie under adequate conditions, the same treatment options would be possible as for patients with a normal resilience capacity level. A smaller proportion (7.9%) of participants had greatly reduced resilience capacity and 0.6% had no resilience (Table 2).

Prevalences of oral disease and treatment

Five percent of younger seniors were edentulous. The mean number of missing teeth (excluding third molars) was 8.6 teeth. A FST Index (number of filled or sound teeth) of 18.8 teeth was recorded for the younger seniors. The degree of restoration for coronal caries was 92.9%, while that of root caries was 62.8%. Dentitions requiring treatment were observed in 20% of participants (Table 3). A total of 20.4% of exposed cervical tooth surfaces showed caries or fillings. The prevalence of root caries was measured at 59.1% (Table 3). The degree of restoration of root caries among younger seniors without severe disabilities or care requirements was 79.8%, and 65.2% among younger seniors with restrictions.

Stage III periodontal disease was observed in 26.3%, while 26.4% had stage IV periodontal disease, with men (III, 30.5%; IV, 31.8%) being more affected than women (III, 22.4%; IV, 21.6%) (Table 3).

Approximately 63.8% of missing teeth were replaced by dental prostheses. Dentitions with missing teeth but no dentures were observed in 4.4% of participants. The most common prosthetic tooth replacement was fixed dental prostheses (47.8%), followed by crown restorations (16.9%), removable partial dentures (19.1%), and complete dentures (10.8%). Additionally, 23.2% of study participants had dental implants, with 2.9% having removable restorations and 20.3% having fixed restorations.

Changes in prevalences of oral diseases

The oral diseases in seniors for DMS IV (2005), DMS V (2014), and DMS • 6 (2023) are shown in Table 4. Edentulism among younger seniors in DMS • 6 (5.0%) was more than halved compared to DMS V and continues the declining trend observed in the previous studies (DMS IV from 2005: 22.6%; DMS V from 2014: 12.4%). The mean number of missing teeth (8.6) among younger seniors further decreased compared to DMS IV (14.1) and DMS V (11.1). At 18.8 teeth, the FST showed an increase among younger seniors compared to the previous studies (DMS IV, 13.6; DMS V, 16.4).

The prevalence of root caries (59.1%) doubled compared to DMS V (28.0%). To assess the occurrence of root caries in teeth at risk, the Root Caries Index (RCI) was 20.4% (DMS IV, 17.0%; DMS V, 13.6%). By contrast, caries experience (decayed, missing, filled teeth [DMFT]: 17.6) remained relatively stable compared to DMS V (17.7). Half of 65- to 74-year-old participants were diagnosed with moderate periodontitis (49.4%) and almost one third (30.4%) had severe periodontitis, according to the Community Periodontal Index (CPI). By comparison, in DMS V, almost half had moderate periodontitis (44.4%), and one fifth (21.7%) had severe periodontitis.

Discussion

The results show that the prevalence of tooth loss and edentulism among younger seniors in Germany continues to decline, reflecting the trend identified in the DMS V.[1,4]

Teeth retained into older age are more susceptible to periodontitis and root caries[15] following gingival recession and the resultant root exposure. In the present study, the prevalence of root caries and severe periodontitis is increasing in younger seniors. The RCI indicating the occurrence of root caries in teeth at risk was slightly increased by 3.4% points. The prevalence of root caries in younger seniors in Germany is no longer decreasing.[16] The global prevalence of root caries is 41%, compared to 34.5% in Germany.[17]

However, not all seniors benefit from the positive developments in dentistry; in particular, people with a degree of disability and those requiring care face a higher burden of oral disease.[18] In the present study, almost half of younger seniors with care requirements exhibited reduced therapeutic capability, and one fifth had greatly reduced oral hygiene ability. Good oral hygiene can contribute to better addressing the challenges of frailty and care dependence. Restricted access to dental treatment and dental care, combined with limited cooperation and suboptimal oral care in this population group, increases the risk of caries, periodontitis, tooth loss, and edentulism compared to the general population.[19]

At the time of observation, only a small proportion of younger seniors required care. Nevertheless, 15% of participating younger seniors had a disability degree of at least 50%.

Table 3 Prevalence of oral diseases and treatments in younger seniors (65- to 74-year-olds)

Variable			Total	Gender	
				Male	Female
Caries experience and care	No. of participants (n)*		797	375	422
	Edentulism (prevalence)		5.0% (3.7; 6.7)	6.4% (4.3; 9.2)	3.8% (2.2; 5.8)
	Caries experience (prevalence, DMFT > 0)		100.0% (NA)	100.0% (NA)	100.0% (NA)
	DMFT		17.6 (17.2; 18.0)	17.4 (16.8; 18.0)	17.9 (17.3; 18.4)
	DT		0.4 (0.3; 0.5)	0.5 (0.3; 0.7)	0.3 (0.3; 0.4)
	MT		8.6 (8.0; 9.2)	8.7 (7.8; 9.5)	8.5 (7.7; 9.3)
	FT		8.6 (8.2; 9.0)	8.2 (7.7; 8.8)	9.0 (8.5; 9.6)
	FST		18.8 (18.2; 19.4)	18.7 (17.8; 19.5)	19.0 (18.2; 19.7)
	ST		10.2 (9.8; 10.6)	10.4 (9.9; 11.0)	9.9 (9.4; 10.4)
	Root caries (prevalence)		59.1% (55.7; 62.5)	61.2% (56.2; 65.8)	57.1% (52.1; 61.7)
	Number of teeth with active root or secondary lesions		0.4 (0.3; 0.4)	0.5 (0.3; 0.6)	0.3 (0.2; 0.3)
	Root Caries Index (%)		20.4 (18.4; 22.3)	20.8 (18.0; 23.6)	20.0 (17.3; 22.6)
	Degree of restoration of coronal caries (%)		92.9 (91.4; 94.3)	91.3 (89.0; 93.7)	94.3 (92.6; 96.0)
	Participants in need of treatment (prevalence, DT > 0)		20.0% (17.4; 23.0)	22.1% (18.2; 26.5)	18.1% (14.6; 22.0)
	Degree of restoration of root caries (%)		76.9 (73.3; 80.6)	73.3 (67.9; 78.7)	80.8 (75.9; 85.7)
Periodontal findings	No. of participants (n)†		718	327	391
	BOP (% sites)		20.4 (18.9; 22.0)	20.8 (18.7; 22.9)	20.0 (17.8; 22.3)
	Mean PD, mm		2.6 (2.6; 2.7)	2.8 (2.7; 2.9)	2.5 (2.4; 2.5)
	Number of teeth with PD ≥ 4 mm		8.3 (7.8; 8.8)	9.8 (9.1; 10.5)	7.0 (6.4; 7.6)
	Number of teeth with PD ≥ 6 mm		1.7 (1.5; 1.9)	2.4 (2.0; 2.8)	1.0 (0.8; 1.3)
	Mean CAL, mm		2.4 (2.3; 2.5)	2.7 (2.5; 2.9)	2.1 (2.0; 2.3)
	Number of teeth with CAL ≥ 3 mm		9.7 (9.2; 10.2)	11.1 (10.3; 11.9)	8.4 (7.8; 9.1)
	Number of teeth with CAL ≥ 5 mm		3.6 (3.2; 3.9)	4.8 (4.2; 5.4)	2.4 (2.0; 2.8)
EFP-AAP periodontitis classification	No. of participants (n)‡		755	348	407
	Periodontal health		0.0% (NA)	0.0% (NA)	0.0% (NA)
	Gingivitis		0.0% (NA)	0.0% (NA)	0.0% (NA)
	Periodontitis cases	All stages	85.2% (74.4; 97.0)	85.3% (70.3; 102.0)	85.1% (70.2; 101.6)
		Stage I	8.3% (6.5; 10.5)	5.7% (3.5; 8.3)	10.7% (7.9; 14.0)
		Stage II	24.2% (21.3; 27.4)	17.4% (13.6; 21.4)	30.5% (26.0; 35.0)
		Stage III	26.3% (23.2; 29.4)	30.5% (26.0; 35.6)	22.4% (18.6; 26.8)
		Stage IV	26.4% (23.4; 29.7)	31.8% (27.1; 36.7)	21.6% (17.7; 25.8)
	Edentulous		5.3% (3.9; 7.1)	6.9% (4.7; 9.9)	3.9% (2.2; 6.0)
	Non-classified§		9.5% (7.5; 11.6)	7.8% (5.4; 10.9)	11.0% (8.1; 14.2)

Data are presented as unweighted numbers (n) and weighted percentages or weighted means (with 95% confidence intervals).
BOP, bleeding on probing; CAL, clinical attachment level; DMFT, decayed, missing, filled teeth; DT, decayed teeth; EFP-AAP, European Federation of Periodontology-American Academy of Periodontology; FST, filled or sound teeth; FT, filled teeth; MT, missing teeth; NA, not available; PD, probing depth; ST, sound teeth.
*Edentate and dentate participants.
†Dentate participants with complete periodontal findings.
‡Edentate and dentate participants with complete periodontal findings.
§Periodontitis case definition not applicable.

Since the population is aging, a higher proportion of people with care requirements can be expected, especially in advanced age. One-third of those requiring care in Germany are very old. Four out of five people requiring care in Germany receive care at home,[6] by relatives, mobile care services, or a combination of both. There are still gaps in knowledge about the oral health of

Table 4 Trends in prevalence of oral diseases in younger seniors (65- to 74-year-olds) from DMS IV, DMS V, and DMS • 6

Variable		DMS IV (2005)	DMS V (2014)	DMS • 6 (2023)
No. of participants (n)*		1,040	1,042	797
Full dentition (base 28, prevalence)		1.1%	0.9%	6.7%
Edentulism (prevalence)		22.6%	12.4%	5.0%
Caries experience and care	DMFT	22.1	17.7	17.6
	DT	0.3	0.5	0.4
	MT	14.1	11.1	8.6
	FT	7.7	6.1	8.6
	FST	13.6	16.4	18.8
	ST	5.9	10.3	10.2
	Root caries (prevalence)	45.0%	28.0%	59.1%
	Root Caries Index (%)	13.6	17.0	20.4
	Degree of restoration of coronal caries (%)	94.8	90.6	92.9
Periodontal findings	No. of participants (n)†	773	902	703
	Mean PD, mm	2.8	2.8	2.8
	No. of teeth with PD ≤ 3 mm	3.1	4.1	4.6
	No. of teeth with PD 4–5 mm	2.7	2.6	2.7
	No. of teeth with PD ≥ 6 mm	0.8	0.5	0.7
Community Periodontal Index (CPI, %)	No. of participants (n)‡	1,013	1,019	740
	CPI 0–2	10.2	21.2	14.8
	CPI 3	37.5	44.4	49.4
	CPI 4	29.1	21.7	30.4

Data are presented as unweighted numbers (n) and weighted percentages or weighted means.
DMFT, decayed, missing, filled teeth; DT, decayed teeth; FST, filled or sound teeth; FT, filled teeth; MT, missing teeth; PD, probing depth; ST, sound teeth.
*Edentate and dentate participants.
†Dentate participants with complete periodontal findings (Partial Mouth Protocol: Index teeth with 3 measurement points).
‡Edentate and dentate participants with complete periodontal findings (Partial Mouth Protocol: Index teeth with 3 measurement points).

these groups; consequently, the implementation of the expert standard "promotion of oral health in care"[20] should be promoted and demanded by dental practitioners across the board.

As more teeth are retained into old age, the challenges for dental care intensify. They include managing periodontal disease, root caries, and prosthodontic restoration, which may still need to be removed by patients and their caregivers in old age.

In the future, equal-opportunity, accessible access to dental care must be provided for the heterogenous group of seniors, particularly in undersupplied and rural areas. The health care system, especially at the interface of medical outpatient and inpatient care, must offer not only dental treatment but also oral care to achieve optimal oral health for people in challenging life circumstances.[19] This represents a major challenge for the health care system in the coming years.

Conclusion

The prevalence of edentulism and tooth loss has continued to decline due to preventive measures, resulting in more teeth being retained into old age. With ongoing morbidity compression, the challenges of preventive dental medicine will lie in preparing younger seniors for advanced age to ensure long-term oral health through proper care abilities.

Disclosure

ARJ and KK are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals.

The interpretation of data and presentation of information was not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. StS is a member of the scientific advisory board of the DMS • 6, was involved in creating the SOP and training the study dentists, and is author of the manuscript. BW is a member of the scientific advisory board of the DMS • 6 and author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. ARJ is the principal investigator of the DMS • 6, is responsible for developing the clinical examinations, and a co-author of the manuscript. HS is a member of the scientific advisory board of the DMS • 6 and a co-author of the manuscript. IN is a member of the scientific advisory board of the DMS V and DMS • 6, was involved in creating the SOP, was co-responsible for developing the clinical examinations for dental prosthetics and senior dentistry, and is a co-author of the manuscript.

References

1. Jordan AR, Stark H, Nitschke I, Micheelis W, Schwendicke F. Epidemiological trends, predictive factors, and projection of tooth loss in Germany 1997–2030: part I. missing teeth in adults and seniors. Clin Oral Investig 2021;25:67–76.

2. Mundt T, Schwahn C, Schmidt CO, Biffar R, Samietz S. Prosthetic tooth replacement in a German population over the course of 11 years: results of the study of health in Pomerania. Int J Prosthodont 2018;31:248–258.

3. Schwendicke F, Nitschke I, Stark H, Micheelis W, Jordan RA. Epidemiological trends, predictive factors, and projection of tooth loss in Germany 1997–2030: part II. Edentulism in seniors. Clin Oral Investig 2020;24:3997–4003.

4. Nitschke I, Stark H. Krankheits- und Versorgungsprävalenzen bei Jüngeren Senioren (65- bis 74-Jährige). Zahnverlust und prothetische Versorgung. In: Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl., 2016.

5. Statistisches Bundesamt (Destatis). Zahl der Pflegebedürftigen steigt bis 2070 deutlich an 2024. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Gesundheit/Pflege/aktuell-vorausberechnung-pflegebeduerftige.html. Accessed 15 Oct 2024.

6. Statistisches Bundesamt (Destatis). 5 Millionen Pflegebedürftige zum Jahresende 2021. https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/12/PD22_554_224.html. Accessed 15 Oct 2024.

7. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl):S4–S12.

8. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

9. Nitschke I. Zur Mundgesundheit von Senioren. Ein epidemiologischer Überblick über ausgewählte orofaziale Erkrankungen und ihre longitudinale Betrachtung. 1st edition. Berlin: Quintessenz, 2006.

10. Jordan AR, Meyer-Lückel H, Kuhr K, Sasunna D, Bekes K, Schiffner U. Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S30–S39.

11. Eickholz P, Holtfreter B, Kuhr K, Dannewitz B, Jordan AR, Kocher T. Prevalence of the periodontal status in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S40–S47.

12. Kocher T, Eickholz P, Kuhr, K, et al. Trends in periodontal status: results from the German Oral Health Studies from 2005 to 2023. Quintessence Int 2025;56(Suppl):S48–S58.

13. Wöstmann B, Samietz S, Jordan AR, Kuhr K, Nitschke H, Stark H. Tooth loss and denture status: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl 1):S60–S68.

14. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

15. Kapellas K, Roberts-Thomson KF. National study of adult oral health 2017–18: root caries. Aust Dent J 2020;65(Suppl 1):S40–S46.

16. Schwendicke F, Krois J, Schiffner U, Micheelis W, Jordan RA. Root caries experience in Germany 1997 to 2014: Analysis of trends and identification of risk factors. J Dent 2018;78:100–105.

17. Maklennan A, Borg-Bartolo R, Roccuzzo AA, et al. Meta-analysis of global distribution of root-caries prevalence in middle-aged and elderly (Epub ahead of print, 16 Dec 2024). Caries Res 2024 doi: 10.1159/000542783.

18. Aida J, Takeuchi K, Furuta M, Ito K, Kabasawa Y, Tsakos G. Burden of oral diseases and access to oral care in an ageing society. Int Dent J 2022;72(4S):S5–S11.

19. Nitschke I, Hahnel S. Zahnmedizinische Versorgung älterer Menschen: Chancen und Herausforderungen. Bundesgesundheitsbl 2021;64:802–811.

20. Büscher A, Blumenberg P, Krebs M, Niemann L-M, Stehling H. Expertenstandard Förderung der Mundgesundheit in der Pflege: Entwicklung – Konsentierung – Implementierung. Osnabrück: Deutsches Netzwerk für Qualitätsentwicklung in der Pflege (DNQP), 2023.

Stefanie Samietz **Bernd Wöstmann**

Stefanie Samietz* Senior Researcher, Clinician, Department of Prosthodontics, Gerodontology and Dental Materials, University Medicine Greifswald, Greifswald, Germany

Bernd Wöstmann* Director and Chair, Department of Prosthodontics, Justus-Liebig-University Giessen, Giessen, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Helmut Stark# Head, Zentrum für ZMK, Department of Prosthodontics, Preclinical Education and Dental Materials Science, University Hospital Bonn, Bonn, Germany

Ina Nitschke# Senior Physician, Gerodontology Section, Department of Prosthetic Dentistry and Materials Science, Leipzig University, Leipzig, Germany

*#The authors contributed equally to the article.

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

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Disease and care prevalence of people with migration history: results of the 6th German Oral Health Study (DMS • 6)

Ghazal Aarabi, Priv-Doz Dr med dent, MSc/Liane Schenk, Prof Dr phil/Kathrin Kuhr, Dr rer medic/
Katrin Borof, MSc/A. Rainer Jordan, Prof Dr med dent, MSc/Berit Lieske, MSc

Objectives: As part of the 6th German Oral Health Study (DMS • 6), the migration history of the study participants was determined at the population level for the first time. **Method and materials:** The evaluation and presentation of migration-related indicators, oral health behavior, and oral diseases were carried out separately for 12-year-olds, 35- to 44-year-olds, and 65- to 74-year-olds. **Results:** When considering the prevalence of disease and care, differences were found between people with and without migration history in all three age groups. The first group had higher prevalences of oral diseases as well as a more complaint-oriented utilization of dental services. **Conclusion:** The data on the prevalence of oral diseases, oral health behavior, and dental service utilization provide evidence that people with migration history do not seem to benefit in the same way from group and individual prophylaxis services as people without migration history. *(Quintessence Int 2025;56(Suppl):S120–S125; doi: 10.3290/j.qi.b5981982)*

Keywords: dental care, dentists, DMS 6, health behavior, human migration, oral health

Germany is a country of immigration that has been shaped by various migration movements in the past and in the present. According to the latest figures of the Federal Statistical Office, people with a history of migration (PwM) made up a quarter of the total population of Germany in 2023, at around 21.2 million people.[1] The term "people with migration history" includes all people who were not born in Germany themselves (immigrants) and/or of whom both parents were not born in Germany (direct descendants of immigrants).[2] Studies on migration and health show that health status and behavior vary depending on migration-related determinants. In terms of oral health, differences can be observed in oral diseases and in the dental service utilization of PwM and people without migration history (PwoM).[3-5]

Looking at social indicators (eg, education, income, profession), the data from the Fifth German Oral Health Study (DMS V) showed social inequalities with regard to the burden of caries and periodontitis in Germany.[6] As part of the 6th German Oral Health Study (DMS • 6), the migration history of the study participants was determined for the first time. To describe health inequalities and identify specific needs of PwM, a differentiated consideration of migration-related and social determinants is essential. Against this background, the present article aimed to present and compare the oral health behavior, the dental service utilization, and the prevalence of oral diseases and care for PwM and PwoM.

Method and materials

The general methodology of the study is presented in separate articles.[7,8] The DMS • 6 has been approved by the Institutional Review Board (IRB) of the Witten/Herdecke University, Witten, Germany (registration number S-249/2021). The present study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

The analysis group consisted of all study participants who met the inclusion criteria in the DMS • 6 analysis set and for whom valid information on the migration history characteristic was available. In total, data from 896 younger adolescents (12-year-olds), 863 younger adults (35- to 44-year-olds), and 753 younger seniors (65- to 74-year-olds) were included in the analysis.

Definition of the variable "migration history"

For migration-sensitive health monitoring, the basic set of indicators was used to record migration-related determinants.[9] For the identification of PwM and PwoM, the items related to their own place of birth ("Which country were you born in?") and that of their parents ("Which country were your parents born in?") were evaluated. PwM are defined as study participants who were not born in Germany or whose parents were not born in Germany.

Statistical analysis

The evaluations were carried out separately for younger adolescents, younger adults, and younger seniors, stratified by migration history (yes/no). For the epidemiologic description of oral diseases, prevalences and means with associated 95% confidence intervals (CIs) were calculated using a weighted dataset. The aim was to compensate for different probabilities in the selection of subjects and differences in gender, age, and region compared to the population in Germany by using the weighted dataset. Descriptive analyses of sociodemographic and migration-related indicators were not weighted.

Numbers (n) are provided without weighting. Detailed information on data handling and statistical methods is described previously.[10]

Results

Sociodemographic and migration-related indicators

Table 1 shows the characteristics of the study participants by migration history for the individual age groups. Among the 12-year-olds (n = 896), 220 younger adolescents (24.6%) had a migration history, of whom 57.7% immigrated themselves (first generation) and 42.3% were direct descendants of immigrants (second generation). Among the 35- to 44-year-olds (n = 863), the proportion of PwM was 23.3% (90.5% first generation, and 9.5% second generation), and among the 65- to 74-year-olds (n = 753), the proportion was 14.0% (69.5% first generation, and 30.5% second generation).

The gender distributions of the two groups were very similar in all age categories. On the other hand, differences were found between PwM and PwoM with respect to education status. The proportion with a low education status was four times higher among 12-year-olds with migration history than among their peers without migration history (22.2% vs 5.2%). The proportion of younger adults with migration history with a low education status was 14.1%, while the proportion of those without migration history was 7.8%. In contrast, among the 65- to 74-year-olds, a lower proportion of people with a low education status (13.5% vs 22.0%) was observed, and instead there was a higher proportion with a medium education status (58.7% vs 47.1%).

The average length of stay of the immigrants was 5.7 years, 16.1 years, and 38.9 years for younger adolescents, younger adults, and younger seniors, respectively. While more than half (53.9%) spoke German plus another language at home, 42.9% of younger adolescents with migration history spoke a different language than German at home. Two thirds of younger adults (66.4%) and younger seniors (66.0%) said they had good to very good German language skills.

Oral hygiene and dental service utilization

The proportion of people with a complaint-oriented dental service utilization was higher for PwM across all age groups (17.9% vs 1.8% for 12-year-olds; 25.1% vs 9.1% for 35- to 44-year-olds; and 24.8% vs 10.7% for 65- to 74-year-olds). PwM also stated more frequently that they had never had their teeth professionally cleaned before (27.8% vs 19.5% for 35- to 44-year-olds; and 27.2% vs 19.4% for 65- to 74-year-olds). In terms of tooth brushing frequency, there was a higher proportion of younger adolescents with migration history, in comparison to PwoM, who brushed their teeth less than twice a day (28.6% vs 11.3%).

Epidemiologic description of oral diseases

The epidemiologic descriptions of oral diseases by migration history are presented in Tables 2 to 4. In the group of 12-year-olds and 35- to 44-year-olds, PwM had more decayed teeth (DT) than PwoM (0.4 vs 0.1 for 12-year-olds; 0.8 vs 0.3 for 35- to 44-year-olds), and a lower degree of restoration of coronal caries (68.1% vs 77.2% for 12-year-olds; 86.6% vs 95.5% for 35- to 44-year-olds). Among the 65- to 74-year-olds, PwM presented fewer DT (0.3 vs 0.4), a higher prevalence of edentulism (9.1% vs 3.8%), more missing teeth (MT) (9.8 vs 8.3), and fewer filled teeth (FT) (7.9 vs 8.9) than PwoM. For the modified Marginal Plaque Index (mMPI), there were higher prevalences among PwM in all age groups compared to PwoM (61.9% vs 47.5% for 12-year-olds; 48.7% vs 41.3% for 35- to 44-year-olds; and 48.5% vs 43.0% for the 65- to 74-year-olds). In addition, there were higher prevalences of bleeding on probing (BOP) and clinical attachment loss (CAL) ≥ 3 mm in the 35- to 44-year-old PwM (19.2% vs 11.8% BOP; 84.2% vs 77.9% CAL ≥ 3 mm) and 65- to 74-year-old PwM (24.2% vs 19.2% BOP; 98.7% vs 94.9% CAL ≥ 3 mm).

Table 1 Baseline characteristics of study participants by migration history in younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds)

Variable		12-year-olds		35- to 44-year-olds		65- to 74-year-olds	
		PwM	PwoM	PwM	PwoM	PwM	PwoM
No. of participants (n)		220	676	201	662	105	648
Age, years		12.8 ± 0.5	12.7 ± 0.5	40.2 ± 3.1	40.0 ± 2.9	69.7 ± 2.8	69.8 ± 2.8
Gender	Male	111 (50.5%)	335 (49.6%)	101 (50.2%)	328 (49.5%)	54 (51.4%)	299 (46.1%)
	Female	109 (49.5%)	340 (50.3%)	100 (49.8%)	333 (50.3%)	51 (48.6%)	349 (53.9%)
	Diverse	0 (0.0%)	1 (0.1%)	0 (0.0%)	1 (0.2%)	0 (0.0%)	0 (0.0%)
Education group	Low	47 (22.2%)	35 (5.2%)	28 (14.1%)	51 (7.8%)	14 (13.5%)	142 (22.0%)
	Medium	107 (50.5%)	310 (46.3%)	82 (41.4%)	319 (48.5%)	61 (58.7%)	304 (47.1%)
	High	58 (27.4%)	324 (48.4%)	88 (44.4%)	288 (43.8%)	29 (27.9%)	199 (30.9%)
Monthly net equivalent Income, Euro		1,214 ± 741	2,296 ± 1,059	2,112 ± 1,452	2,530 ± 1,382	1,819 ± 990	2,029 ± 1,049
Migration history	1st generation (immigrated to Germany themselves)	127 (57.7%)	NA	182 (90.5%)	NA	73 (69.5%)	NA
	2nd generation (both parents born outside Germany)	93 (42.3%)	NA	19 (9.5%)	NA	32 (30.5%)	NA
Length of stay, years		5.7 ± 3.1	NA	16.1 ± 10.7	NA	38.9 ± 16.0	NA
Language spoken at home	German	7 (3.2%)	605 (89.8%)	NA	NA	NA	NA
	Other	94 (42.9%)	1 (0.1%)	NA	NA	NA	NA
	German + other	118 (53.9%)	68 (10.1%)	NA	NA	NA	NA
Self-assessment of German language skills	Very good	NA	NA	63 (37.7%)	NA	10 (21.3%)	NA
	Good	NA	NA	48 (28.7%)	NA	21 (44.7%)	NA
	Moderate	NA	NA	32 (19.2%)	NA	7 (14.9%)	NA
	Limited	NA	NA	20 (12.0%)	NA	6 (12.8%)	NA
	None	NA	NA	4 (2.4%)	NA	3 (6.4%)	NA
Smoking status	Current smoker	NA	NA	57 (28.6%)	163 (24.6%)	14 (13.3%)	96 (14.8%)
	Former smoker	NA	NA	33 (16.6%)	138 (20.8%)	46 (43.8%)	239 (36.9%)
	Never smoked	NA	NA	109 (54.8%)	361 (54.5%)	45 (42.9%)	313 (48.3%)
Self-assessment of oral health status	Very good/good	146 (67.0%)	548 (81.3%)	126 (63.6%)	507 (76.8%)	64 (61.0%)	417 (64.5%)
	Moderate/poor/very poor	72 (33.0%)	126 (18.7%)	72 (36.4%)	153 (23.2%)	41 (39.0%)	230 (35.5%)
Dental service utilization	Control-oriented	179 (82.1%)	662 (98.2%)	149 (74.9%)	602 (90.9%)	79 (75.2%)	578 (89.3%)
	Complaint-oriented	39 (17.9%)	12 (1.8%)	50 (25.1%)	60 (9.1%)	26 (24.8%)	69 (10.7%)
Professional tooth cleaning (utilization)	Yes	NA	NA	139 (71.6%)	532 (80.5%)	73 (70.9%)	519 (80.5%)
	No	NA	NA	54 (27.8%)	129 (19.5%)	28 (27.2%)	125 (19.4%)
Tooth brushing (frequency)	≥ 2 times daily	157 (71.4%)	599 (88.7%)	147 (73.9%)	563 (85.1%)	78 (81.3%)	512 (83.8%)
	< 2 times daily	63 (28.6%)	76 (11.3%)	52 (26.1%)	99 (14.9%)	18 (18.8%)	99 (16.2%)
Interdental cleaning (frequency)	≥ once daily	32 (14.5%)	103 (15.3%)	59 (29.6%)	156 (23.6%)	28 (29.2%)	244 (40.0%)
	< once daily	188 (85.5%)	572 (84.7%)	140 (70.4%)	505 (76.4%)	68 (70.8%)	366 (60.0%)

Data are presented as number (percentage) or mean ± standard deviation based on unweighted data.
NA, not available; PwM, people with migration history; PwoM, people without migration history.

Discussion

Differences in disease and care prevalence between PwM and PwoM were found in all three age groups. PwM had higher prevalences of oral diseases as well as a more complaint-oriented utilization of dental services. These are the first nationwide representative survey results in Germany.

There are few studies on oral health among younger adolescents with migration history. In a cross-sectional study among 12-year-old pupils with migration history from secondary schools in Heidelberg, data on caries experience comparable to that of the DMS • 6 were obtained.[11] In this case, the younger adolescents with migration history had an average DMFT (decayed, missing, filled teeth) value of 1.3 and a DT of 0.4.[11] Looking at the 12-year-olds without migration history, however, the younger adolescents with a DMFT of 0.9 and a DT of 0.1 had significantly higher values than their peers of the DMS • 6. The higher values could be due to differences in education status,

since the pupils from Heidelberg were recruited exclusively in low-income areas. In addition, the data from the study date back to 2004 and are therefore older. Data from the DMS indicate a continuous decline in caries in 12-year-olds (DMS IV: 0.7 DMFT, 0.2 DT; DMS V: 0.5 DMFT, 0.1 DT; DMS • 6: 0.2 DMFT, 0.1 DT), which could explain the differences.[6,12] In another study on dental health of 12-year-old pupils from the Ennepe-Ruhr district, hardly any changes in the DMFT values and the proportion of caries-free dentition occurred among pupils with a Turkish migration history between 1993 and 2003.[13] In contrast, there was a demonstrable increase in the proportion of caries-free dentition among pupils without migration history. Significant differences in the caries experience between younger adolescents with and without migration history can be observed in further studies.[14-16] The available studies provide evidence that the caries prevalence among 12-year-olds in Germany is declining; this does not apply equally to younger adolescents with migration history. However, direct comparisons to the DMS • 6 are difficult due to differences in age groups, regional limitations, and different operationalizations of migrant groups.

The data of the DMS • 6 also indicate that there is a persistent increase in the risk of inadequate dental service utilization and inadequate tooth brushing frequency in younger adolescents with migration history. The proportion of younger adolescents with migration history who brush their teeth less than twice a day is 2.5 times higher than that of younger adolescents without migration history. Similar trends can also be observed in the data from the KiGGS study.[17,18] Here, the proportion of participants with migration history with an inadequate tooth brushing frequency is almost twice as high as those without migration history, whereby persons between the ages of 0 to 17 were included.

The available data on the oral health of middle-aged and older people with a history of migration in Germany are insufficient to date. Initial study results among seniors and adults with migration history report significantly higher DMFT values, more plaque, higher BOP values, and lower dental service utilization compared to PwoM.[5,19-21] In the Hamburg-based MuMi study, PwM (average age 38.7 years) had an Approximal Plaque Index (API) of 52.5 and a degree of caries restoration of 81.7%.[5] In contrast, PwoM (mean age 44.0 years) performed significantly better, with an API of 38.3 and a degree of caries restoration of 93.8%. The differences between PwoM and PwM are somewhat more pronounced in the MuMi study in contrast to the 35- to 44-year-olds of the DMS • 6. In comparison to the DMS • 6, the subjects of the MuMi study were preferentially recruited in districts with a high proportion of migrants. International studies also indicate poorer dental health in migrant populations.[4,22]

Table 2 Epidemiologic description and treatment of oral diseases in younger adolescents (12-year-olds) by migration history

Variable	PwM	PwoM
Caries-free (prevalence, DMFT = 0)	52.2% (46.5; 58.2)	87.9% (85.1; 90.3)
DMFT	1.3 (1.1; 1.5)	0.2 (0.2; 0.3)
DT	0.4 (0.3; 0.5)	0.1 (0.0; 0.1)
MT	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
FT	0.9 (0.7; 1.0)	0.2 (0.1; 0.2)
Degree of restoration of coronal caries (%)	68.1 (60.9; 75.3)	77.2 (67.9; 86.5)
MIH (prevalence)	9.2% (6.2; 13.1)	16.4% (13.6; 19.6)
mMPI (% segments with plaque)	61.9 (58.9; 64.9)	47.5 (45.3; 49.6)

Data are presented as weighted percentages or weighted means (with 95% confidence intervals). DMFT, decayed, missing, filled teeth; DT, decayed teeth; FT, filled teeth; MIH, molar incisor hypomineralization; mMPI, modified Marginal Plaque Index; MT, missing teeth; PwM, people with migration history; PwoM, people without migration history.

Table 3 Epidemiologic description and treatment of oral diseases in younger adults (35-44-year-olds) by migration history

Variable	PwM	PwoM
No. of teeth	26.1 (25.8; 26.4)	26.8 (26.7; 27.0)
Edentulism (prevalence)	0.0% (NA)	0.1% (0.0; 0.8)
Caries-free (prevalence, DMFT = 0)	3.8% (1.8; 6.5)	8.4% (6.4; 10.8)
DMFT	8.7 (8.0; 9.3)	8.0 (7.6; 8.5)
DT	0.8 (0.6; 1.0)	0.3 (0.3; 0.4)
MT	1.6 (1.3; 1.9)	0.7 (0.6; 0.9)
FT	6.3 (5.7; 6.8)	7.0 (6.6; 7.3)
FST	25.3 (24.9; 25.7)	26.5 (26.3; 26.7)
ST	19.0 (18.4; 19.7)	19.5 (19.1; 20.0)
Degree of restoration of coronal caries (%)	86.6 (83.1; 90.1)	95.5 (94.4; 96.5)
Root caries (prevalence)	12.5% (8.8; 17.0)	13.5% (10.9; 16.3)
mMPI (% segments with plaque)	48.7 (45.7; 51.7)	41.3 (39.4; 43.2)
BOP (% sites)	19.2 (16.5; 21.8)	11.8 (10.7; 13.0)
Mean PD (mm)	2.3 (2.2; 2.4)	2.0 (2.0; 2.1)
Mean CAL (mm)	1.2 (1.1; 1.4)	1.0 (1.0; 1.1)
CAL ≥ 3 mm (prevalence)	84.2% (79.3; 88.5)	77.9% (74.5; 81.1)

Data are presented as weighted percentages or weighted means (with 95% confidence intervals). BOP, bleeding on probing; CAL, clinical attachment level; DMFT, decayed, missing, filled teeth; DT, decayed teeth; FST, filled and sound teeth; FT, filled teeth; mMPI, modified Marginal Plaque Index; MT, missing teeth; NA, not available; PD, probing depth; PwM, people with migration history; PwoM, people without migration history; ST, sound teeth.

Conclusion

The higher prevalence of oral diseases among PwM and the less frequent utilization of dental services provide evidence that PwM do not benefit from group and individual prophylaxis ser-

Table 4 Epidemiologic description and treatment of oral diseases by migration history in younger seniors (65–74-year-olds)

Variable	PwM	PwoM
No. of teeth	18.1 (16.6; 19.7)	19.5 (18.9; 20.2)
Edentulism (prevalence)	9.1% (5.1; 15.1)	3.8% (2.6; 5.6)
Caries-free (prevalence, DMFT = 0)	0.0% (NA)	0.0% (NA)
DMFT	17.9 (16.8; 19.0)	17.6 (17.2; 18.1)
DT	0.3 (0.1; 0.4)	0.4 (0.3; 0.5)
MT	9.8 (8.2; 11.4)	8.3 (7.7; 8.9)
FT	7.9 (6.8; 8.9)	8.9 (8.5; 9.4)
FST	17.8 (16.3; 19.4)	19.1 (18.4; 19.7)
ST	10.0 (8.9; 11.1)	10.2 (9.8; 10.6)
Degree of restoration of coronal caries (%)	94.6 (91.5; 97.7)	93.2 (91.7; 94.8)
Root caries (prevalence)	56.0% (47.6; 64.5)	59.8% (55.9; 63.6)
mMPI (% segments with plaque)	48.5 (43.0; 53.9)	43.0 (40.7; 45.2)
BOP (% sites)	24.2 (20.1; 28.3)	19.2 (17.6; 20.9)
Mean PD (mm)	2.7 (2.6; 2.9)	2.6 (2.5; 2.7)
Mean CAL (mm)	2.4 (2.2; 2.7)	2.4 (2.3; 2.5)
CAL≥ 3 mm (prevalence)	98.7% (95.5; 99.9)	94.9% (92.6; 96.4)

Data are presented as weighted percentages or weighted means (with 95% confidence intervals). BOP, bleeding on probing; CAL, clinical attachment level; DMFT, decayed, missing, filled teeth; DT, decayed teeth; FST, filled and sound teeth; FT, filled teeth; mMPI, modified Marginal Plaque Index; MT, missing teeth; NA, not available; PD, probing depth; PwM, people with migration history; PwoM, people without migration history; ST, sound teeth.

vices in the same way as PwoM. Background information on potential barriers to access and migration-related factors influencing oral health (length of stay, origin, circumstances of migration, language skills) must be included in future analyses. This would also make it possible to better reflect the diversity of PwM.[9,23] For example, studies on the oral health of younger adolescents with migration history show differences in caries experience when differentiated by country of origin,[14,16,24] which have not yet been considered here.

Due to the increase in the number of immigrants in Germany, it can be assumed that dental practices will be faced with an additional need for treatment. To improve the dental care of PwM in Germany, more structural and individual attention is needed to promote equal access to preventive measures.

Disclosure

KK and ARJ are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there is no conflict of interests according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information is not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors read and approved the final manuscript. GA is a member of the scientific advisory board of the DMS • 6 and the author of the manuscript. LS is a member of the scientific advisory board of the DMS • 6 and was co-responsible for the conceptualization of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. KB is co-responsible for the preparation of the analysis plan. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. BL is a co-author of the manuscript.

References

1. Statistisches Bundesamt. Statistischer Bericht – Mikrozensus – Bevölkerung nach Einwanderungsgeschichte – Erstergebnisse 2023. Wiesbaden; 2024. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Migration-Integration/Publikationen/Downloads-Migration/statistischer-bericht-einwanderungsgeschichte-erst-5122126237005.html. Accessed 30 Jan 2025.

2. Fachkommission der Bundesregierung zu den Rahmenbedingungen der Integrationsfähigkeit. Gemeinsam die Einwanderungsgesellschaft gestalten. Bericht der Fachkommission der Bundesregierung zu den Rahmenbedingungen der Integrationsfähigkeit. Berlin; 2020. https://www.fachkommission-integrationsfaehigkeit.de/fk-int/dokumente/bericht-der-fachkommission-integrationsfaehigkeit-1880150. Accessed 30 Jan 2025.

3. Lauritano D, Moreo G, Carinci F, Campanella V, Della Vella F, Petruzzi M. Oral health status among migrants from middle- and low-income countries to Europe: a systematic review. Int J Environ Res Public Health 2021;18:12203.

4. Pabbla A, Duijster D, Grasveld A, Sekundo C, Agyemang C, van der Heijden G. Oral Health status, oral health behaviours and oral health care utilisation among migrants residing in Europe: a systematic review. J Immigr Minor Health 2021;23:373–388.

5. Spinler K, Weil M-T, Valdez R, et al. Mundgesundheitskompetenz von Menschen mit Migrationshintergrund – Erste Auswertungen der MuMi-Studie. Bundesgesundheitsbl 2021;64:977–985.

6. Jordan AR, Micheelis W (eds). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Cologne: Deutscher Zahnärzte Verl.; 2016.

7. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025; 56(Suppl): S4–S12.

8. Ohm C, Kuhr K, Zimmermann F, et al.. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.

9. Kajikhina K, Koschollek C, Sarma N, et al. Empfehlungen zur Erhebung und Analyse migrationsbezogener Determinanten in der Public-Health-Forschung. J Health Monit 2023;8:55–77.

10. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.

11. Bissar A-R, Schulte AG, Muhjazi G, Koch MJ. Caries prevalence in 11- to 14-year old migrant children in Germany. Int J Public Health 2007;52:103–108.

12. Micheelis W, Schiffner U (eds). Vierte Deutsche Mundgesundheitsstudie (DMS IV). Neue Ergebnisse zu oralen Erkrankungsprävalenzen, Risikogruppen und zum zahnärztlichen Versorgungsgrad in Deutschland 2005. Cologne: Deutscher Zahnärzte Verl.; 2006.

13. Heinrich-Weltzien R, Kühnisch J, Goddon I, Senkel H, Stösser L. Zahngesundheit deutscher und türkischer Schüler – ein 10-Jahres-Vergleich. Gesundheitswesen 2007;69:105–109.

14. Bissar A-R, Oikonomou C, Koch MJ, Schulte AG. Dental health, received care, and treatment needs in 11- to 13-year-old children with immigrant background in Heidelberg, Germany. Int J Paediatr Dent 2007; 17:364–370.

15. Kühnisch J, Senkel H, Heinrich-Weltzien R. Vergleichende Untersuchung zur Zahngesundheit von deutschen und ausländischen 8- bis 10-Jährigen des westfälischen Ennepe-Ruhr-Kreises. Gesundheitswesen 2003;65: 96–101.

16. van Steenkiste M, Becher A, Banschbach R, Gaa S, Kreckel S, Pocanschi C. Prävalenz von Karies, Fissurenversiegelungen und Füllungsmaterial bei deutschen Kindern und Kindern von Migranten. Gesundheitswesen 2004;66:754–758.

17. Knopf H, Rieck A, Schenk L. Mundhygiene. Daten des KiGGS zum Kariespräventiven Verhalten. Bundesgesundheitsbl 2008;51:1314–1320.

18. Krause L, Kuntz B, Schenk L, Knopf H. Oral health behaviour of children and adolescents in Germany. Results of the cross-sectional KiGGS Wave 2 study and trends. J Health Monit 2018;3:3–19.

19. Aarabi G, Reissmann DR, Seedorf U, Becher H, Heydecke G, Kofahl C. Oral health and access to dental care: a comparison of elderly migrants and non-migrants in Germany. Ethn Health 2018;23:703–717.

20. Brzoska P, Erdsiek F, Waury D. Enabling and predisposing factors for the utilization of preventive dental health care in migrants and non-migrants in Germany. Front Public Health 2017;5:201.

21. Erdsiek F, Waury D, Brzoska P. Oral health behaviour in migrant and non-migrant adults in Germany: the utilization of regular dental check-ups. BMC Health 2017;17:84.

22. Delgado-Angulo EK, Marcenes W, Harding S, Bernabé E. Ethnicity, migration status and dental caries experience among adults in East London. Community Dent Oral Epidemiol 2018;46:392–399.

23. Schumann M, Kajikhina K, Polizzi A, et al. Konzepte für ein migrationssensibles Gesundheitsmonitoring. J Health Monit 2019;4:51–67.

24. Achenbach M. Mundgesundheit von Immigrant*innen aus den Anwerbestaaten und aus der ehemaligen Sowjetunion in Deutschland – eine explorative Pilotstudie auf der Grundlage der Daten der Fünften Deutschen Mundgesundheitsstudie (DMS V) [Thesis]. Berlin: Alice Salomon Hochschule; 2024.

Ghazal Aarabi

Ghazal Aarabi Chief Senior Physician, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, Medical Center Hamburg-Eppendorf, Hamburg, Germany

Liane Schenk Professor, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Institute of Medical Sociology and Rehabilitation Science, Berlin, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Katrin Borof Research Assistant, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, Medical Center Hamburg-Eppendorf, Hamburg, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Berit Lieske Research Assistant, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, Medical Center Hamburg-Eppendorf, Hamburg, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
Email: dms6@idz.institute

Association between migration history and oral health: results of the 6th German Oral Health Study (DMS • 6)

Berit Lieske, MSc/Liane Schenk, Prof Dr phil/Kathrin Kuhr, Dr rer medic/Vinay Pitchika, PhD/Katrin Borof, MSc/A. Rainer Jordan, Prof Dr med dent, MSc/Ghazal Aarabi, Priv-Doz Dr med dent, MSc

Objectives: Studies have demonstrated a significant association between migration history and oral health. Even after adjusting for confounders, migration history remains an independent risk factor for poorer oral health. As part of the 6th German Oral Health Study (DMS • 6), disease and care prevalence among individuals with migration history was surveyed at the population level. This article aims to assess the relationship between migration history, education status, and oral health. **Method and materials:** The analyses of the relationship between migration history and various oral health outcomes were conducted separately for younger adolescents (12-year-olds), adults (20-year-olds, 35- to 44-year-olds, 43- to 52-year-olds), and seniors (65- to 74-year-olds, 73- to 82-year-olds). **Results:** A significant association between migration history and poorer oral health outcomes, as well as less favorable oral health behaviors, was observed across all age groups. After adjusting for age, gender, and education, individuals with migration history exhibited higher levels of plaque, more bleeding sites, a higher prevalence of decayed teeth, insufficient tooth brushing frequency, and complaint-oriented dental service utilization. **Conclusion:** Previous studies have consistently identified education as a risk factor for poorer oral health. In the present study, even after adjusting for education status in multivariate models, the association between migration history and oral health outcomes remained significant. This finding underscores migration history as an independent risk factor for poorer oral health outcomes. This is the first large-scale cohort study in Germany to analyze the relationship between migration history and multiple oral health outcomes across different age groups. Future research should focus on uncovering migration-related factors, health literacy, and health behaviors to better explain the observed differences and improve oral health for migrant populations. *(Quintessence Int 2025;56 (Suppl):S126–S134; doi: 10.3290/j.qi.b5982024)*

Keywords: cross-sectional studies, dental care, dentists, DMS 6, education, epidemiology, health behavior, human migration, oral health

Previous international and national studies have demonstrated a significant association between migration history and oral health.[1-5] Even after adjusting for education and socioeconomic status, migration history was identified as an independent risk factor for poorer oral health outcomes.

In a previous article, cross-sectional data from the 6th German Oral Health Study (DMS • 6) on oral health, dental service utilization, and the prevalence of oral diseases among people with migration history (PwM) and people without migration history (PwoM) were analyzed and compared.[6] The data from the DMS • 6 cross-sectional arm were analyzed separately for younger adolescents (12-year-olds), younger adults (35- to 44-year-olds), and younger seniors (65- to 74-year-olds). The results revealed differences in disease and care prevalence between PwM and PwoM across all three age groups. PwM exhibited higher prevalence of oral diseases as well as a more complaint-oriented dental service utilization.

In the present paper, the relationship between migration history and various oral health outcomes is reported using current data from the DMS • 6, considering other relevant social determinants such as age, gender, and education. Cross-sectional data from all observed age groups—derived from both the cross-

sectional component and the cohort component of the DMS • 6—were utilized. The results are stratified for younger adolescents (12-year-olds), adults (20-year-olds, 35- to 44-year-olds, 43- to 52-year-olds), and seniors (65- to 74-year-olds, 73- to 82-year-olds).

Method and materials

The general methodology of the study has been described previously.[7,8] The 6th German Oral Health Study (DMS • 6) has been approved by the Institutional Review Board (IRB) of Witten/Herdecke University, Witten, Germany (registration number S-249/2021). This study is registered at the German Clinical Trials Register (registration number DRKS00028701).

Sample

Study participants were included in the statistical analyses if they met the inclusion criteria of the DMS • 6 analysis set and provided complete data on migration history (PwM/PwoM), age (years), gender (male/female), and education status (low/medium/high). In total, 62 of 958 younger adolescents, 115 of 1,640 adults and 76 of 1,170 seniors were excluded due to missing data. Consequently, 879 younger adolescents, 1,525 adults, and 1,094 seniors were included in the analyses.

Variables

Definition of the variable "migration history"

For migration-sensitive health monitoring, the basic set of indicators was used to record migration-related determinants.[9] For the identification of PwM and PwoM, the items related to their own place of birth ("Which country were you born in?") and that of their parents ("Which country were your parents born in?") were evaluated. PwM are defined as study participants:

- who were not born in Germany (immigrants) or
- whose parents were not born in Germany (direct descendants of immigrants).

The analysis collective consisted of all study participants who fulfilled the inclusion criteria and for whom valid information on the characteristic migration history was available.

Oral health outcomes

For the analysis of the research question, clinical and behavioral oral health indicators from the clinical examination and the interviews were selected, specific to each age group:

- number of teeth (adults: < 28 teeth / 28 teeth; seniors: < 20 teeth / ≥ 20 teeth)
- number of sound teeth (ST), younger adolescents
- number of decayed teeth (DT; DT = 0 / DT ≥ 1), all age groups
- modified Marginal Plaque Index (mMPI, % segments with plaque), younger adolescents
- mean probing depth (PD, mm), partial recording protocol: index teeth with three sites, adults and seniors
- mean clinical attachment level (CAL, mm), partial recording protocol, adults and seniors
- bleeding on probing (BOP, % sites), partial recording protocol, adults and seniors
- root caries (yes / no), seniors
- self-assessment of oral health status ([very good/good] / [moderate/poor/very poor]), all age groups
- tooth brushing frequency (< 2 times daily / ≥ 2 times daily), all age groups
- interdental cleaning frequency (< once daily / ≥ once daily), all age groups
- dental service utilization (complaint-oriented/control-oriented), all age groups.

The definition of the variables is described in detail elsewhere.[10-13]

Statistical analysis

Descriptive analyses of sociodemographic variables and oral health outcomes were conducted separately for younger adolescents, adults, and seniors, stratified by migration history (PwM/PwoM).

Multiple association analyses were performed across the different age groups to evaluate the relationship between migration history (exposure of interest) and the aforementioned oral health outcomes (specific to each age group). Appropriate statistical models were selected based on the distribution of the outcome variable, including generalized linear models with Gaussian or gamma distribution, Poisson regressions with robust standard errors, and fractional probit regressions. Mixed-effects regression models were employed to estimate the associations between migration history and the oral health outcomes. These models accounted for covariates such as age, gender, and education (fixed effects) and incorporated a composite region variable as a random effect. The analyses followed a stepwise approach:

- Step 1: Basic models assessing the association between migration history (exposure) and the oral health outcome without any adjustments.

Table 1 Baseline characteristics of study participants and oral health outcomes in adults by migration history

Variable		PwM	PwoM
No. of participants (n)		280	1,245
Age, years		38.0 ± 8.6	37.3 ± 10.5
Gender	Male	139 (49.6%)	621 (49.9%)
	Female	141 (50.4%)	624 (50.1%)
Education group	Low	39 (13.9%)	80 (6.4%)
	Medium	142 (50.7%)	796 (63.9%)
	High	99 (35.4%)	369 (29.6%)
Monthly net equivalent income, Euro		2,021 ± 1,344	2,348 ± 1,378
Migration history	Without migration history	0 (0.0%)	1,245 (100.0%)
	1st generation (immigrated to Germany themselves)	217 (77.5%)	0 (0.0%)
	2nd generation (both parents born outside Germany)	63 (22.5%)	0 (0.0%)
Smoking status	Never smoked	159 (57.0 %)	751 (60.3%)
	Former smoker	44 (15.8%)	217 (17.4%)
	Current smoker	76 (27.2%)	277 (22.2%)
Self-assessment of oral health status	Very good/good	187 (67.3%)	979 (78.8%)
	Moderate/poor/very poor	91 (32.7%)	264 (21.2%)
Dental service utilization	Complaint-oriented	67 (24.0 %)	99 (8.0 %)
	Control-oriented	212 (76.0 %)	1,146 (92.0 %)
Professional tooth cleaning (utilization)	Yes	200 (73.0 %)	931 (74.8 %)
	No	72 (26.3%)	305 (24.5%)
	Don't know	2 (0.7%)	8 (0.6%)
Tooth brushing (frequency)*	≥ 2 times daily	213 (76.3%)	1,072 (86.1%)
	< 2 times daily	66 (23.7%)	173 (13.9%)
Interdental cleaning (frequency)*	≥ once daily	78 (28.0 %)	273 (21.9%)
	< once daily	201 (72.0 %)	972 (78.1%)
No. of teeth		26.4 ± 2.7	26.9 ± 2.2
	< 28 teeth	136 (48.6%)	428 (34.4%)
	28 teeth	144 (51.4%)	817 (65.6%)
DT		0.6 ± 1.4	0.4 ± 1.1
	DT = 0	214 (76.4%)	1,031 (82.8%)
	DT > 0	66 (23.6%)	214 (17.2%)
Mean PD, mm		2.4 ± 0.6	2.2 ± 0.5
Mean CAL, mm		1.4 ± 1.0	1.2 ± 0.8
BOP (% sites)		14.9 ± 16.8	11.3 ± 14.0

Data are presented as numbers (percentages) or mean ± standard deviation based on unweighted data for participants with valid information on migration history, age, gender, and education.
BOP, bleeding on probing; CAL, clinical attachment level; DT, decayed teeth; PD, probing depth; PwM, people with migration history; PwoM, people without migration history.
*Dentate study participants.

- Step 2: The models were adjusted for age (adults and seniors only) and gender.
- Step 3: Further adjustment was made by including education status in the model to account for socioeconomic differences.

The results were presented as unstandardized coefficients (b) or prevalence ratios (PR) along with their 95% confidence intervals (CIs) and *P* values. Additional methodologic details are provided in Appendix 1.

All analyses were based on unweighted data. Detailed information on data handling and statistical methods is described previously.[14]

Results

Descriptive characteristics

Descriptive characteristics of the 12-year-olds stratified by migration history were detailed in a previous article.[6] Table 1 provides the characteristics of the adults (20-year-olds, 35- to 44-year-olds, 43- to 52-year-olds) and Table 2 outlines those of the seniors (65- to 74-year-olds, 73- to 82-year-olds).

Sociodemographic and migration-related indicators

Among the 12-year-olds (n = 879), 220 younger adolescents (24.6%) had a history of migration, of whom 57.7% were immigrants themselves (first generation) and 42.3% were direct descendants of immigrants (second generation). Among the adults (n = 1,525), 280 participants (18.4%) had a history of migration, with 77.5% being first-generation and 22.5% second-generation immigrants. For the seniors (n = 1,094), the proportion of PwM was 12.8% (72.1% first generation; 27.9% second generation).

The age and gender distributions between PwM and PwoM were consistent across all age groups. However, disparities in education status were evident. Among the 12-year-olds, the proportion with a low education status was four times higher among PwM compared to PwoM (22.2% vs 5.2%). For adults, this proportion was twice as high (13.9% vs 6.4%), yet adult PwM also had a higher proportion of participants with a high education status compared to PwoM (35.4% vs 29.6%). For the seniors, the proportion with a low education status was lower among PwM than PwoM (20.0% vs 25.1%). Additionally, the monthly net equivalent income was lower for PwM compared to PwoM across both adults (€2,021 vs €2,348) and seniors (€1,779 vs €2,004).

Oral hygiene and dental service utilization

The proportion of participants with complaint-oriented dental service utilization was three times as high for adult PwM (24.0% vs 8.0%) and twice as high for senior PwM (22.1% vs 11.1%) compared to PwoM. Within the senior group, PwM stated more frequently that they had never had their teeth professionally cleaned compared to PwoM (28.3% vs 20.4%). This difference was not observed in the adult sample (26.3% vs 24.5%). Regarding tooth brushing frequency, the proportion of adults brushing less than twice daily was almost twice as high among PwM compared to PwoM (23.7% vs 13.9%). However, for the seniors, tooth brushing frequency distributions were similar between the groups.

Epidemiologic description of oral diseases

For the younger adolescents, the epidemiologic description of oral diseases has been published elsewhere.[1] The data for the adults and seniors are presented in Tables 1 and 2. Among the adults, PwM exhibited more decayed teeth than PwoM (DT: 0.6 vs 0.4), whereas the seniors showed the opposite trend (0.4 vs 0.5 for PwM vs PwoM). PwM seniors also had less root caries (55.0% vs 62.9%). BOP was higher among PwM in both adults (14.9% vs 11.3%) and seniors (23.4% vs 18.9%). The average CAL was higher for adults with PwM (1.4 mm vs 1.2 mm), but showed no differences for the seniors (2.8 mm vs 2.8 mm).

Regression analyses

Younger adolescents

After adjusting for gender and education, the younger adolescents with migration history had a significantly higher prevalence of decayed teeth (DT > 0) (PR = 5.1 [95% CI 2.6; 10.0]), $P < .001$) and a higher mMPI (B = 9.2 [4.9; 13.4], $P < .001$) compared to younger adolescents without migration history. Moreover, the Poisson regression analyses confirmed that migration history was significantly associated with a higher prevalence of a tooth brushing frequency of less than twice daily (PR = 2.36, $P < .001$) and a complaint-oriented dental service utilization (PR = 9.30, $P < .001$), even after adjusting for gender and education status (Table 3).

Adults

Among the adults, PwM had a significantly higher prevalence of decayed teeth (DT ≥ 1) (PR = 1.36, $P = .005$), a tooth brushing frequency of less than twice daily (PR = 1.58, $P < .001$), and a complaint-oriented utilization behavior (PR = 2.69, $P < .001$), after adjusting for age, gender, and education. Furthermore, regression analyses revealed a significant association between migration history and higher mean CAL (b = 0.15, $P = .008$) and BOP (b = 0.15, $P = .002$; Table 3).

Seniors

For seniors, regression analyses revealed a significant association between migration history and higher BOP (b = 0.18, $P = .017$), after adjusting for age, gender, and education. No significant asso-

Table 2 Baseline characteristics of study participants and oral health outcomes in seniors by migration history

Variable		PwM	PwoM
No. of participants (n)		140	954
Age, years		71.9 ± 4.7	72.5 ± 4.8
Gender	Male	67 (47.9%)	449 (47.1%)
	Female	73 (52.1%)	505 (52.9%)
Education group	Low	28 (20.0 %)	239 (25.1%)
	Medium	73 (52.1%)	441 (46.2%)
	High	39 (27.9%)	274 (28.7%)
Monthly net equivalent income, Euro		1,779 ± 932	2,004 ± 1,030
Migration history	Without migration history	0 (0.0%)	954 (100.0%)
	1st generation (immigrated to Germany themselves)	101 (72.1%)	0 (0.0%)
	2nd generation (both parents born outside Germany)	39 (27.9%)	0 (0.0%)
Smoking status*	Never smoked	44 (42.3%)	312 (48.4%)
	Former smoker	46 (44.2%)	239 (37.1%)
	Current smoker	14 (13.5%)	94 (14.6%)
Self-assessment of oral health status	Very good/good	83 (59.3%)	628 (65.9%)
	Moderate/poor/very poor	57 (40.7%)	325 (34.1%)
Dental service utilization	Complaint-oriented	31 (22.1%)	106 (11.1%)
	Control-oriented	109 (77.9%)	847 (88.9%)
Professional tooth cleaning (utilization)	Yes	97 (70.3%)	753 (79.4%)
	No	39 (28.3%)	193 (20.4%)
	Don't know	2 (1.4%)	2 (0.2%)
Tooth brushing (frequency)†	≥ 2 times daily	102 (82.9%)	743 (83.7%)
	< 2 times daily	21 (17.1%)	145 (16.3%)
Interdental cleaning (frequency)†	≥ once daily	38 (30.9%)	349 (39.3%)
	< once daily	85 (69.1%)	539 (60.7%)
Number of teeth		18.0 ± 9.0	19.1 ± 8.0
	< 20 teeth	58 (41.4%)	364 (38.2%)
	≥ 20 teeth	82 (58.6%)	590 (61.8%)
Edentulism	Yes	14 (10.0%)	44 (4.6%)
	No	126 (90.0%)	910 (95.4%)
DT		0.4 ± 1.1	0.5 ± 1.4
	DT = 0	115 (82.1%)	746 (78.2%)
	DT > 0	25 (17.9%)	208 (21.8%)
Root caries	Yes	77 (55.0%)	600 (62.9%)
	No	49 (35.0%)	310 (32.5%)
Mean PD, mm		2.9 ± 0.9	2.7 ± 0.8
Mean CAL, mm		2.8 ± 1.4	2.8 ± 1.5
BOP (% sites)		23.4 ± 21.8	18.9 ± 19.7

Data are presented as numbers (percentages) or mean ± standard deviation based on unweighted data for participants with valid information on migration history, age, gender, and education.
BOP, bleeding on probing; CAL, clinical attachment level; DT, decayed teeth; PD, probing depth; PwM, people with migration history; PwoM, people without migration history.
*Not assessed for older seniors (73- to 82-year-olds).
†Dentate study participants.

ciation was found for mean CAL (b = 0.01, *P* = .825). In addition, the Poisson regression to assess the association between migration history and the prevalence of decayed teeth showed no significant association (PR = 1.05, *P* = .145). This also applies to the prevalence of root caries (PR = 1.14, *P* = .363) and tooth brushing frequency (PR = 1.07, *P* = .777). Yet, just like the other

age groups, migration history was significantly associated with a higher prevalence of complaint-oriented dental service utilization (PR = 2.01, $P < .001$), even after adjusting for age, gender, and education (Table 3).

Discussion

The present study identified a significant association between migration history and poorer oral health outcomes and behaviors across all age groups. After adjusting for age (for adults and seniors), gender, and education, PwM exhibited more plaque (in younger adolescents), more bleeding sites (in adults and seniors), and a higher prevalence of decayed teeth, insufficient tooth brushing frequency, and complaint-oriented dental service utilization.

Comparable data on the relationship between migration history and various oral health outcomes for younger adolescents are rare. The KiGGS Wave 2 study found that children and adolescents (aged 0 to 17 years) with migration history had a significantly higher chance of insufficient tooth brushing frequency (odds ratio [OR] = 1.94) and low utilization of regular dental check-ups (OR = 1.56) compared to their peers without migration history.[15] Similarly, the DMS • 6 study showed that younger adolescents with migration history had a significantly higher prevalence of insufficient tooth brushing frequency (less than two times daily) (PR = 2.36) and complaint-oriented dental service utilization (PR = 9.30). These findings thus indicate a higher likelihood of insufficient oral hygiene within the group of younger adolescents with a history of migration. However, the KiGGS study included a broader age range (0 to 17 years) and employed different parameters to measure oral health behavior, which limits direct comparability with the findings presented here.

Available data on the association between migration history and oral health outcomes in adults and seniors are also scarce. In a cross-sectional survey of a large German-speaking cohort (ages 18 to over 80), migration history was associated with a reduced chance of attending regular dental check-ups after adjusting for demographic and socioeconomic factors (OR = 0.71; multiple logistic regression).[16,17] Importantly, this study adjusted for narrower age ranges compared to the DMS • 6 data. However, the results in adults and seniors presented here also showed that migration history was associated with a reduced chance of control-oriented dental service utilization, reflecting similar trends. These patterns are consistent with international studies, although a lot of the research focuses on ethnicity rather than migration history, a distinction that should not be overlooked.[4,18,19]

In the Hamburg-based MuMi intervention study, adults without migration history had a significantly higher chance of having good to optimal approximal plaque indices (APIs) compared to those with migration history (OR = 1.75; mean age 44.0 years for PwoM and mean age 38.7 years for PwM).[1] Among the adults in the DMS • 6 cohort, PwoM had a significantly higher prevalence of brushing their teeth at least twice daily compared to PwM. Research suggests that tooth brushing frequency is closely associated with plaque removal efficacy.[20]

In a cross-sectional explorative study among migrants in Hamburg (mean age 69.7 years), migrants had, on average, three more decayed teeth than nonmigrants, even after adjusting for age, gender, income, education, and number of teeth.[3] However, the PwM seniors in the DMS • 6 cohort had fewer decayed teeth and did not show a higher prevalence of decayed teeth compared to PwoM of the same age group. These differing results may be explained by differences in education status: In the Hamburg study, a higher proportion of migrants had a lower education status (10 years or less) compared to nonmigrants. In contrast, in the DMS • 6 cohort, a larger proportion of PwoM had a low education status (25.1% for PwoM vs 20.0% for PwM). Moreover, the proportion of first generation immigrants in the DMS • 6 cohort was lower compared to those of the Hamburg-based study (72% vs 100%).

Education status is a well-established risk factor for poorer oral health.[21-23] Studies have shown that migrant populations tend to have a lower education status than those without migration history.[24] The statistical models presented here were thus adjusted for education status, yet the association between migration history and oral health outcomes remained significant. This reinforces the notion of migration history as an independent risk factor for poorer oral health, consistent with previous research.[3,25]

In addition to whether a person or their parents were born in Germany or not, further migration-related factors (eg, origin, length of stay, circumstances of migration, level of acculturation, language proficiency) should also be considered in future studies. For instance, in a study examining the interrelationship between ethnicity, migration history, and dental caries, Delgado-Angulo et al[19] found that, among foreign-born participants, age at arrival and length of residence were positively associated with DMFT (decayed, missing, filled teeth).

Conclusion

To the best of the present authors' knowledge, this is the first large cohort study to analyze the association between migra-

Table 3 Association analyses between migration history and different oral health outcomes by age groups

Age group	Dependent variable		Step 1: crude estimate		Step 2: adjusted for gender		Step 3: adjusted for gender and education	
			Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value	Estimate (95% CI)	*P* value
Younger adolescents (12-year-olds)	Sound teeth (n)*		b = 0.00 (−0.02; 0.03)	.731	b = 0.01 (−0.02; 0.03)	.701	b = 0.01 (−0.02; 0.03)	.661
	Decayed teeth (ref. DT = 0)†	DT ≥ 1	PR = 5.58 (3.34; 9.32)	< .001	PR = 5.57 (3.32; 9.35)	< .001	PR = 5.06 (2.57; 9.98)	< .001
	mMPI (% segments with plaque)‡		b= 11.1 (7.0; 15.2)	< .001	b = 11.0 (6.9; 15.2)	< .001	b= 9.2 (4.9; 13.4)	< .001
	Self-assessment of oral health status (ref. very good/good)†	Moderate/poor/ very poor	PR = 1.77 (1.53; 2.04)	< .001	PR = 1.75 (1.54; 2.00)	< .001	PR = 1.71 (1.45; 2.01)	< .001
	Tooth brushing frequency (ref. ≥ 2 times daily)†	< 2 times daily	PR = 2.45 (1.68; 3.57)	< .001	PR = 2.44 (1.68; 3.55)	< .001	PR = 2.36 (1.61; 3.45)	< .001
	Interdental cleaning frequency (ref. ≥ once daily)†	< once daily	PR = 1.00 (0.94; 1.06)	.985	PR = 1.00 (0.94; 1.06)	.994	PR = 1.01 (0.95; 1.06)	.816
	Dental service utilization (ref. control-oriented)†	Complaint-oriented	PR = 11.73 (5.67; 24.29)	< .001	PR = 11.73 (5.67; 24.28)	< .001	PR = 9.30 (4.06; 21.30)	< .001
Adults (20-year-olds, 35- to 44-year-olds, 43- to 52-year-olds)	Number of teeth (ref. 28 teeth)†	< 28 teeth	PR = 1.42 (1.21; 1.66)	< .001	PR = 1.39 (1.20; 1.60)	< .001	PR = 1.35 (1.16; 1.56)	< .001
	Decayed teeth (ref. DT = 0)†	DT ≥ 1	PR = 1.48 (1.16; 1.88)	.002	PR = 1.43 (1.11; 1.86)	.006	PR = 1.36 (1.10; 1.69)	.005
	Mean CAL, mm*¶		b = 0.16 (0.04; 0.28)	.006	b = 0.16 (0.05; 0.27)	.005	b = 0.15 (0.04; 0.26)	.008
	Mean PD, mm‡¶		b = 0.22 (0.16; 0.29)	< .001	b = 0.21 (0.14; 0.27)	< .001	b = 0.19 (0.13; 0.25)	< .001
	BOP (% sites)§¶		b= 0.17 (0.08; 0.27)	< .001	b = 0.16 (0.06; 0.25)	.001	b = 0.15 (0.05; 0.24)	.002
	Self-assessment of oral health status (ref. very good/good)†	Moderate/poor/ very poor	PR = 1.55 (1.27; 1.88)	< .001	PR = 1.51 (1.26; 1.79)	< .001	PR = 1.41 (1.21; 1.66)	< .001
	Tooth brushing frequency (ref. ≥ 2 times daily)†‖	< 2 times daily	PR = 1.71 (1.35; 2.17)	< .001	PR = 1.66 (1.33; 2.08)	< .001	PR = 1.58 (1.28; 1.96)	< .001
	Interdental cleaning frequency (ref. ≥ once daily)†‖	< once daily	PR = 1.27 (1.01; 1.61)	.043	PR = 1.24 (1.00; 1.55)	.052	PR = 1.28 (1.04; 1.57)	.022
	Dental service utilization (ref. control-oriented)†	Complaint-oriented	PR = 3.02 (2.27; 4.01)	< .001	PR = 2.91 (2.22; 3.81)	< .001	PR = 2.69 (2.04; 3.54)	< .001
Seniors (65- to 74-year-olds, 73- to 82-year-olds)	Number of teeth (ref. ≥ 20 teeth)†	< 20 teeth	PR = 1.09 (0.87; 1.36)	.468	PR = 1.10 (0.88; 1.38)	.384	PR = 1.11 (0.89; 1.40)	.346
	Decayed teeth (ref. DT = 0)†	DT ≥ 1	PR = 1.05 (0.98; 1.13)	.180	PR = 1.05 (0.98; 1.13)	.167	PR = 1.05 (0.98; 1.13)	.145
	Mean CAL, mm*¶		b = 0.00 (−0.11; 0.11)	.959	b = 0.01 (−0.10; 0.12)	.856	b = 0.01 (−0.10; 0.12)	.825
	Mean PD, mm‡¶		b = 0.11 (−0.05; 0.26)	.184	b = 0.11 (−0.05; 0.26)	.179	b = 0.12 (−0.03; 0.28)	.121
	BOP (% sites)§¶		b= 0.18 (0.03; 0.33)	.022	b = 0.17 (0.02; 0.32)	.025	b = 0.18 (0.03; 0.33)	.017
	Root caries (ref. no)†#	Yes	PR = 1.16 (0.88; 1.52)	.304	PR = 1.13 (0.85; 1.51)	.406	PR = 1.14 (0.86; 1.52)	.363
	Self-assessment of oral health status (ref. very good/good)†	Moderate/poor/ very poor	PR = 1.19 (0.93; 1.53)	.163	PR = 1.19 (0.93; 1.52)	.160	PR = 1.19 (0.94; 1.51)	.146
	Tooth brushing frequency (ref. ≥ 2 times daily)†‖	< 2 times daily	PR = 1.06 (0.64; 1.73)	.828	PR = 1.05 (0.65; 1.68)	.855	PR = 1.07 (0.67; 1.71)	.777
	Interdental cleaning frequency (ref. ≥ once daily)†‖	< once daily	PR = 1.13 (1.06; 1.21)	< .001	PR = 1.14 (1.05; 1.23)	.001	PR = 1.15 (1.07; 1.24)	< .001
	Dental service utilization (ref. control-oriented)†	Complaint-oriented	PR = 1.96 (1.51; 2.55)	< .001	PR = 1.95 (1.52; 2.50)	< .001	PR = 2.01 (1.60; 2.53)	< .001

Three separate models were calculated for each exposure/oral health outcome combination. Estimates are given for exposure = migration history (people with migration history vs people without migration history [reference]). Unweighted data set including study participants with valid information on migration history, age, gender, and education.
b, unstandardized regression coefficient; BOP, bleeding on probing; CAL, clinical attachment level; CI, confidence interval; DT, decayed teeth; mMPI, modified Marginal Plaque Index; PD, probing depth; PR, prevalence ratio.
*Model specifications: mixed-effects generalized linear model, family (gamma) link (log).
†Model specifications: mixed-effects generalized linear model, family (Poisson) link (log), robust standard errors.
‡Model specifications: mixed-effects generalized linear model, family (Gaussian), covariance = identity.
§Model specifications: fractional probit regression; excluding random effect.
‖Dentulous study participants.
¶ Partial recording protocol: index teeth with 3 sites.
#Excluding study participants without gingival recession.

tion history and multiple oral health outcomes across different age groups. A significant association between migration history and poorer oral health outcomes, as well as poorer oral health behaviors, has been shown after adjusting for age, gender, and education. These findings suggest that migration history is a crucial factor contributing to disparities in oral health out-

comes, highlighting the need for targeted oral health interventions. Future research should focus on uncovering migration-related factors, health literacy, and health behaviors to better explain the observed differences and improve oral health for migrant populations.

Disclosure

KK and ARJ are employed by the National Association of Statutory Health Insurance Dentists (KZBV). The authors declare that there are no conflicts of interest according to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The interpretation of data and presentation of information was not influenced by any personal or financial relationship with any individual or organization.

Author contributions

All authors listed in the paper have contributed sufficiently to fulfill the criteria for authorship according to the Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals (ICMJE Recommendations). All authors have read and approved the final manuscript. BL is the author of the manuscript. LS is a member of the scientific advisory board of the DMS • 6 and a co-author of the manuscript. KK is the deputy principal investigator of the DMS • 6, responsible for the data analysis, and a co-author of the manuscript. VP is responsible for the data-analysis and a co-author of the manuscript. KB is a co-author of the manuscript. ARJ is the principal investigator of the DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript. GA is a member of the scientific advisory board of DMS • 6, responsible for developing the clinical examinations, and a co-author of the manuscript.

References

1. Spinler K, Weil M-T, Valdez R, et al. Mundgesundheitskompetenz von Menschen mit Migrationshintergrund – Erste Auswertungen der MuMi-Studie. Bundesgesundheitsbl 2021;64:977–985.
2. Aarabi G, Walther C, Kretzler B, Zwar L, König H-H, Hajek A. Association between migration and oral health-related quality of life: results from a nationally representative online survey. BMC Oral Health 2022;22:309.
3. Aarabi G, Reissmann DR, Seedorf U, Becher H, Heydecke G, Kofahl C. Oral health and access to dental care: a comparison of elderly migrants and non-migrants in Germany. Ethn Health 2018;23:703–717.
4. Lauritano D, Moreo G, Carinci F, Campanella V, Della Vella F, Petruzzi M. Oral Health status among migrants from middle- and low-income countries to Europe: a systematic review. Int J Environ Res Public Health 2021;18:12203.
5. Lauritano D, Moreo G, Martinelli M, Campanella V, Arcuri C, Carinci F. Oral health in migrants: an observational study on the oral health status of a migrant cohort coming from middle- and low-income countries. Appl Sci 2022;12:5774.
6. Aarabi G, Schenk L, Kuhr K, Borof K, Jordan AR, Lieske B. Disease and care prevalence of people with migration history: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl): S120–S125.
7. Jordan AR, Frenzel Baudisch N, Ohm C, et al. 6th German Oral Health Study (DMS • 6): rationale, study design, and baseline characteristics. Quintessence Int 2025;56(Suppl): S4–S12.
8. Ohm C, Kuhr K, Zimmermann F, et al. 6th German Oral Health Study (DMS • 6): fieldwork, data collection, and quality assurance. Quintessence Int 2025;56(Suppl):S14–S21.
9. Kajikhina K, Koschollek C, Sarma N, et al. Empfehlungen zur Erhebung und Analyse migrationsbezogener Determinanten in der Public-Health-Forschung. J Health Monit 2023;8:55–77.
10. Jordan AR, Meyer-Lückel H, Kuhr K, Sasunna D, Bekes K, Schiffner U. Caries experience and care in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S30–S39.
11. Deinzer R, Jordan AR, Kuhr K, Margraf-Stiksrud J. Oral hygiene behavior and toothbrushing skills: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S82–S87.
12. Eickholz P, Holtfreter B, Kuhr K, Dannewitz B, Jordan AR, Kocher T. Prevalence of the periodontal status in Germany: results of the 6th German Oral Health Study (DMS • 6). Quintessence Int 2025;56(Suppl):S40–S47.
13. Kocher T, Eickholz P, Kuhr K, et al. Trends in periodontal status: results from the German Oral Health Studies from 2005 to 2023. Quintessence Int 2025;56(Suppl): S48–S58.
14. Kuhr K, Sasunna D, Frenzel Baudisch N, et al. 6th German Oral Health Study (DMS • 6): data processing and statistical methods. Quintessence Int 2025;56(Suppl):S22–S29.
15. Krause L, Kuntz B, Schenk L, Knopf H. Oral health behaviour of children and adolescents in Germany. Results of the cross-sectional KiGGS Wave 2 study and trends. J Health Monit 2018;3:3-19.
16. Erdsiek F, Waury D, Brzoska P. Oral health behaviour in migrant and non-migrant adults in Germany: the utilization of regular dental check-ups. BMC Oral Health 2017;17:84.
17. Brzoska P, Erdsiek F, Waury D. Enabling and predisposing factors for the utilization of preventive dental health care in migrants and non-migrants in Germany. Front Public Health 2017;5:201.

18. Arora G, Mackay DF, Conway DI, Pell JP. Ethnic differences in oral health and use of dental services: cross-sectional study using the 2009 Adult Dental Health Survey. BMC Oral Health 2016;17:1.

19. Delgado-Angulo EK, Marcenes W, Harding S, Bernabé E. Ethnicity, migration status and dental caries experience among adults in East London. Community Dent Oral Epidemiol 2018;46:392–399.

20. Axelsson P, Nyström B, Lindhe J. The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. J Clin Periodontol 2004;31:749–757.

21. Paulander J, Axelsson P, Lindhe J. Association between level of education and oral health status in 35-, 50-, 65- and 75-year-olds. J Clin Periodontol 2003;30:697–704.

22. Minervini G, Franco R, Marrapodi MM, Di Blasio M, Ronsivalle V, Cicciù M. Children oral health and parents education status: a cross sectional study. BMC Oral Health 2023;23:787.

23. Walther C, Spinler K, Borof K, et al. Evidence from the Hamburg City Health Study: association between education and periodontitis. BMC Public Health 2022;22:1662.

24. Gries T, Redlin M, Zehra M. Educational assimilation of first-generation and second-generation immigrants in Germany. J Int Migr Integr 2022;23:815–845.

25. Aarabi G, Reißmann DR, Heydecke G, Farhan D, Kofahl C. Die Mundgesundheit von Menschen mit Migrationshintergrund in Deutschland - eine kritische Betrachtung. Dtsch Zahnarztl Z 2013;68:280–287.

Berit Lieske

Berit Lieske Research Assistant, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, Medical Center Hamburg-Eppendorf, Hamburg, Germany

Liane Schenk Professor, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Institute of Medical Sociology and Rehabilitation Science, Berlin, Germany

Kathrin Kuhr Head of statistics, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Vinay Pitchika Research Associate, Department of Conservative Dentistry and Periodontology, LMU Hospital, Munich, Germany

Katrin Borof Research Assistant, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, Medical Center Hamburg-Eppendorf, Hamburg, Germany

A. Rainer Jordan Scientific director, Institut der Deutschen Zahnärzte (IDZ), Cologne, Germany

Ghazal Aarabi Chief Senior Physician, Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, Medical Center Hamburg-Eppendorf, Hamburg, Germany

Correspondence: Institut der Deutschen Zahnärzte, DMS • 6 Study Group, Universitätsstraße 73, D-50931 Cologne, Germany.
E-mail: dms6@idz.institute

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Appendix 1

Additional data available at: https://www.idz.institute/publikationen/online-journal-zahnmedizin-forschung-und-versorgung/association-between-migration-history-and-oral-health-results-of-the-6th-german-oral-health-study-dms-6-online-appendix/.

DMS • 6 Surveillance Investigators Group

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German Dental Association (Bundeszahnärztekammer, BZÄK) and National Association of Statutory Health Insurance Dentists (Kassenzahnärztliche Bundesvereinigung, KZBV)

Principal investigators
Andreas Rainer Jordan, Kathrin Kuhr
Project management
Cristiana Ohm
Primary scientific responsibility in dentistry
Andreas Rainer Jordan
Primary scientific responsibility in social science
Nicolas Frenzel Baudisch, Fabian Zimmermann
Primary statistical responsibility
Kathrin Kuhr
Data management
Dominic Sasunna
Field project management
Constanze Cholmakow-Bodechtel
Field project management assistant
Linda Scharf, Katja Reimann
Data management (field operations)
Marvin Krämer
Field operations
Cerner Enviza (now Oracle Life Sciences), Munich (Germany)
Coordinating center
Institut der Deutschen Zahnärzte (IDZ), Cologne (Germany)
Scientific advisory board
Katrin Bekes, Peter Eickholz, Katrin Hertrampf, Christian Kirschneck, Thomas Kocher, Hendrik Meyer-Lückel, Ina Nitschke, Stefanie Samietz, Ulrich Schiffner, Frank Schwarz, Helmut Stark, Bernd Wöstmann
Extended scientific advisory board
Ghazal Aarabi, Renate Deinzer, Laura Krause, Joachim Krois, Stefan Listl, Wolfgang Rathmann, Jutta Margraf-Stiksrud, Liane Schenk, Falk Schwendicke, Stefan Zimmer
Scientific advisors
Birte Holtfreter, Vinay Pitchika
Data privacy protection
Thomas Bachmann
Online data entry software (DentaSoft 6)
Michaela Förster
Field supervisor
Christian Blome
Field monitor
Elisabeth Füßl-Grünig, Constanze Cholmakow-Bodechtel
Public relations
Stephanie Mayer, Martina Gürtner
Field contact persons
Peter Brietsche, Joachim Schulze, Ute Krause, Barbara Koller; Anja Gaede
Field interviewers
Jonathan Cyba, Benana Senjikdar, Anja Gaede, Ronny Jolak, Yasser AlMohammad, Ammar Makia
Clinical investigators
Andrea Eberhard, Simone Strein, Lucas Szabo, Leonard Kohl, Nesreen Mohamed

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