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

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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)*

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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-

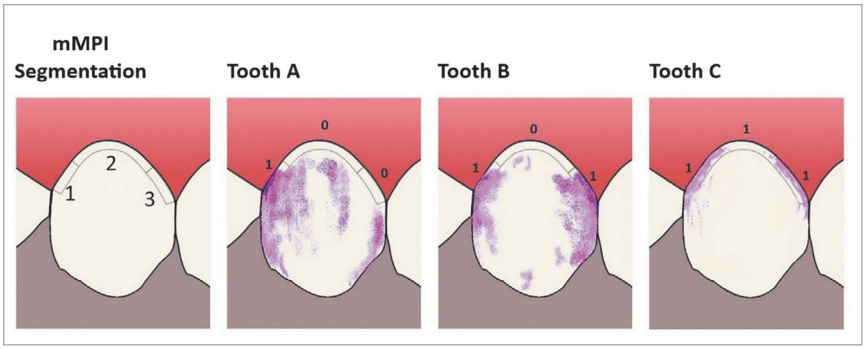

Fig 1 Recording of the modified Marginal Plaque Index (mMPI). In the case of tooth A, plaque is only present in segment 1, in tooth B in segments 1 and 3, and in tooth C in all three segments.

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.

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