

Oral health in German children, adolescents, adults and senior citizens in 2005

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Objective: The aim of this field study (the “Fourth German Oral Health Study”) was to obtain representative data on caries (DMFT index), periodontitis (CPI) and prosthetic status in the German population and to evaluate changes in the oral health of the German people as compared with the findings of the Third German Oral Health Study conducted eight years previously. **Basic research design:** The study took the form of a population-representative cross-sectional survey with random samples, and was complemented by a questionnaire to reveal sociological as well as behavioural data. **Participants:** The age cohorts in the present study were 12-year-olds (children), 15-year-olds (adolescents), 35- to 44-year-olds (adults) and 65- to 74-year-olds (senior citizens). **Results:** All age groups showed considerable improvements in oral health with respect to caries. Of the children, 70.1 % were free of dentine caries and the mean DMFT value was 0.7. In adults and senior citizens both the DMFT value and the number of missing teeth and edentulousness declined. With regard to periodontal conditions, increasing prevalence of moderate and severe findings was recorded in adults and senior citizens, owing probably to the larger number of natural teeth remaining in the oral cavity. **Conclusion:** The study documents a distinct improvement in oral health in the German population. Interrelated with the higher numbers of remaining natural teeth a higher prevalence of moderate and severe periodontal conditions in German adults and senior citizens was observed.

Key words: Adolescent, adult, aged, child, dental caries, epidemiologic study, oral health, periodontitis, prosthodontics.

Introduction

Oral health is influenced by a number of different variables, such as preventive and restorative regimes, patient information and health-related behaviour, as well as the approach to dental care. Some of these variables are subject to change over time, resulting in altered oral health outcomes. Demographic shifts in age structure will also affect the need for changes in oral health care in many countries. It is therefore appropriate for the main indicators of oral health to be redetermined periodically.

Many recent epidemiological field studies in industrialized countries have revealed a decline in caries experience in children and adolescents (Pitts *et al.*, 2006; WHO, 2007a). The same applies to the number of missing teeth or the prevalence of edentulousness in adults and senior citizens (Österberg *et al.*, 2006; Suominen-Taipale *et al.*, 1999). In the case of periodontitis, however, the prevalence of pathological findings differs considerably between countries (WHO, 2007b).

In Germany, oral health indicators such as caries prevalence, periodontitis, the number of missing teeth and edentulousness were determined by a nationwide representative epidemiological study in 1997 (Institut der Deutschen Zahnärzte, 1999). It was found that caries in 12-year-old children had declined since the early 1990s. In adults and senior citizens the number of missing teeth had fallen slightly, whereas both caries experience and periodontal conditions were unchanged compared with former studies.

The present study was conducted to obtain representative data on caries, periodontitis and prosthetic status in the German population with a view to comparing them with the previous study from 1997. It is referred to as “DMS IV” (Deutsche Mundgesundheitsstudie IV, the Fourth German Oral Health Study). The data are intended to permit valid comparison as a basis for assessment of changes in the oral health of the German population (Institut der Deutschen Zahnärzte, 2006).

Material and methods

Samples

The study was carried out in the form of a population-representative cross-sectional survey of four age cohorts, which were selected on the basis of the relevant WHO criteria (WHO, 1997) and the customary principles of international oral epidemiology: 12-year-olds (children); 15-year-olds (adolescents); 35–44-year-olds (adults); and 65–74-year-olds (senior citizens). Except for the adolescents, these age cohorts were also included in the study conducted eight years previously.

Random samples were taken systematically from the records of the population registration offices in a total of 90 municipalities (sample points), which in turn constituted a cluster random sample based on region and degree of urbanization. Consent forms were sent to a total of 7,342 persons. Three project teams were deployed for the clinical examinations and the sociological survey,

each comprising a calibrated dentist, an interviewer and an "arranger/organizer". Calibration was carried out under the direction of a group of experts (in the fields of cariology, periodontology and prosthodontics), to provide the appropriate professional framework for the study. The findings were recorded and coded in accordance with definitions given in an examination manual. All findings were saved in situ on a laptop.

Epidemiological examination

The field period was February to September 2005. On three occasions during the field period some participants were examined by the experts in duplicate for estimation of data reliability. To evaluate inter-examiner reproducibility Kendall's tau correlation was calculated for caries, Cohen's kappa coefficient for the CPI and the contingency coefficient C for the prosthetic findings.

The study was divided into two parts, comprising the clinical dental examination and a sociological survey respectively. For the latter, participants were asked to complete a questionnaire themselves. Owing to language barriers (difficulty in understanding the questionnaire), the survey data relate to the resident population of German nationality.

The target variables of the clinical examination were caries experience, which was determined in accordance with WHO criteria (WHO, 1997); periodontal conditions (not examined in children), as determined by the CPI (WHO, 1997); and the number of missing teeth as well as total edentulousness in the adult aged and senior populations. This paper presents the core information on caries experience (DMFT), the percentage of participants with maximum CPI scores of 3 (pocket depth 4–5 mm) and 4 (pocket depth \geq 6 mm) respectively, and tooth loss and prosthetic replacement.

The figures were evaluated by the SPSS program. The values obtained were compared for gender-related differences by the U (Mann-Whitney) test or the χ^2 test.

Results

A total of 4,631 randomly chosen subjects from all four age cohorts consented, were examined and surveyed. This corresponds to a response rate of 63.1%. There was a high level of agreement between the investigators and the calibrating experts ($\tau = 0.85$ for DMFT, Cohen's kappa coefficient = 0.94 for maximum CPI scores, contingency coefficient C = 0.86 for the prosthetic findings). The distribution of subjects by gender and age cohorts is shown in table 1.

Caries experience as expressed by the DMFT value averaged 0.7 in the cohort of children, 1.8 in the adolescents, 14.5 in the adults and 22.1 in the senior citizens (Table 2). The teeth of 70.1 % of the children and 46.1 % of the adolescents were found to be free of dentine caries experience (DMFT = 0, Table 3).

The percentage of subjects with maximum CPI scores of 3 or 4 is shown in table 4. As many as 13.4 % of adolescents exhibited one of these findings, although their periodontitis was mainly moderate (12.6%). In adults, 52.7% and 20.5% respectively had at least one tooth with a maximum pocket depth of score 3 or score 4, while this

was the case in 48.0% and 39.8% respectively of senior citizens. In all age cohorts, a CPI of 4 was observed more frequently in male than in female subjects, the difference reaching significance level in seniors.

With regard to tooth loss among the adult population, the study found that the average number of missing teeth in the adult cohort was 2.7 and among senior citizens 14.2 (table 5). These figures exclude wisdom teeth. Total edentulousness (i.e. complete absence of teeth in both upper and lower jaws) was observed in 1.0 % of the members of the adult cohort and in 22.6% of the senior citizens. Missing teeth had been replaced with fixed or removable appliances in 48.5% of the adult cohort and 88.7% of the senior citizens' cohort.

Discussion

An important feature of the present investigation is that it uses the same method as an earlier field study conducted eight years previously (Institut der Deutschen Zahnärzte, 1999). A wide range of validated comparisons is permitted by this maximization of methodological consistency with respect to both clinical and sociological variables.

The study was carried out following randomized sampling in four age cohorts in 90 sample points in Germany, reflecting the regional structure of the country as a whole. Sampling was based on government population files. The net response rate of the epidemiological field survey was 63.1 %. Following extensive non-response analyses using a self-administrated questionnaire with five basic questions to the non-responders on oral-health behaviour, prosthetic treatment and socio-demographic factors, the rate for core information was increased to 72.6% (Institut der Deutschen Zahnärzte, 2006). The non-responder analyses which, based on sociological as well as behavioural data, gives evidence that the results of the study show no signs of biased sampling.

Initial contact to the randomly selected study participants was by invitation letter. For this reason, and because the medical sociological questionnaire was written in German, the study reflects findings applicable to the population of German nationality only; the findings cannot be attributed to persons with foreign nationality which was 8.8% in 2005 (Statistisches Bundesamt Deutschland, 2007). People with migration background but German nationality were included in the study. Finally, this approach conforms to the method of the earlier nationwide study (DMS III) in 1997, which is taken as the primarily reference in our study.

For determination of caries prevalence, cavities involving dentine were recorded, in accordance with WHO criteria (WHO, 1997). In this way, the teeth of 70.1 % of the children and 46.1 % of the adolescents were found to be totally lacking in dentine caries experience. Caries experience in 12-year-old children (DMFT) fell considerably as compared with the 1997 study, from 1.7 to 0.7. This is one of the lowest figures for caries experience hitherto reported in any country in the world (WHO, 2007a). Caries prevalence in German children can thus be characterized as "very low" on the WHO scale (WHO, 1984).

Table 1. Distribution of the study participants by gender and age cohorts

	Number of participants		
	Total	Male	Female
Children	1383	708	675
Adolescents	1283	658	625
Adults	925	471	454
Senior citizens	1040	488	552

Table 2. Caries experience (DMFT) in German children, adolescents, adults and senior citizens, 1997 and 2005

	Mean (\pm SD) DMFT scores				
	Total (1997)	Total (2005)	Male	Female	<i>p</i> *
Children	1.7 (2.1)	0.7 (1.5)	0.7 (1.5)	0.7 (1.4)	0.156
Adolescents	..**	1.8 (2.6)	1.6 (2.4)	2.0 (2.8)	0.006
Adults	16.1 (5.9)	14.5 (5.7)	14.0 (6.0)	15.1 (5.4)	0.005
Senior citizens	23.6 (5.3)	22.0 (6.0)	21.2 (6.5)	22.9 (5.2)	0.001

* Comparing males vs females, U test

** Age cohort not examined

Table 3. Percentage of caries free children and adolescents (DMFT = 0)

	1997				2005			
	Total	Male	Female	<i>p</i> *	Total	Male	Female	<i>p</i> *
Children	41.8	43.6	40.0	0.241	70.1	71.4	68.7	0.991
Adolescents	..**	..**	..**	..**	46.1	49.7	42.4	0.008

* Comparing males vs females, χ^2 test

** Age cohort not examined

Table 4. Prevalence (%) of German adolescents, adults, and senior citizens with at least one moderate (mod) or severe (sev) periodontitis site in 1997 and 2005

	1997		2005		Males		Females		<i>p</i> *	
	mod	sev	mod	sev	mod	sev	mod	sev	mod	sev
Adolescents	..**	..**	12.6	0.8	13.6	1.2	11.5	0.5	0.270	0.258
Adults	32.2	14.1	52.7	20.5	57.2	21.8	48.2	19.1	0.007	0.317
Senior citizens	39.7	24.4	48.0	39.8	46.7	45.4	49.2	34.6	0.513	0.002

* Comparing males vs females, χ^2 test

** Age cohort not examined

Table 5. Mean number of missing teeth (mis, SD in parentheses) and prevalence of edentulousness (edt, %) in German adults and senior citizens in 1997 and 2005 (excluding wisdom teeth)

	1997		2005		Males		Females		<i>p</i> *	
	mis	edt	mis	edt	mis	edt	mis	edt	mis	edt
Adults	4.2 (2.6)	1.1	2.7 (4.0)	1.0	2.7 (4.2)	1.1	2.8 (3.9)	0.8	0.705 **	0.078 ***
Senior citizens	17.6 (9.1)	24.8	14.2 (9.8)	22.6	13.3 (9.9)	19.6	14.9 (9.7)	25.2	0.001 **	0.034 ***

* Comparing males vs females

** U test *** χ^2 test

One explanation of the significant decline in caries seems to be the increased use of fissure sealing (Wendt *et al.*, 2001) and regular visits to the dentist for check-ups. A total of 71.7 % of the children had at least one fissure-sealed tooth – an increase of 18.8 percentage points over 1997, when 52.9 % of the children had at least one sealed fissure (Institut der Deutschen Zahnärzte, 1999). In 2005, the importance of tooth sealing was reflected in a DMFT value of only 0.6 in children with at least one sealed fissure, while children with no sealing had 1.1 DMF teeth. Children who claimed in the questionnaire to visit the dentist regularly for check-ups had a mean DMFT of 0.6, compared with children who visited dentists mainly for the relief of pain who had a mean DMFT of 1.0.

In 12- and 15-year-olds, the substantial decline in caries is accompanied by an increasingly skewed distribution of the caries burden. This polarization of caries experience confirms earlier studies (Institut der Deutschen Zahnärzte, 1999). However, in children the high-risk group with more than two DMF teeth has fallen since 1997 from one fifth to one tenth of the cohort (10.2 %), who account for 61.1 % of the caries experience. In adolescents covered by a representative national sample for the first time, 26.8 % of subjects had 79.2 % of all DMF teeth.

In adults as well as senior citizens, the study for the first time reveals a decline in caries experience. This significant decline is attributable to the smaller number of caries-related extractions (the M component of the DMFT index). Significant equalization of the caries burden in German adults as between the old and the new Federal *Länder* (the former West and East Germany respectively) has occurred since 1997 (Institut der Deutschen Zahnärzte, 1999). In all age groups except for the 12-year-olds female subjects have significantly higher caries experience than males.

Periodontal conditions were recorded by various variables and indices like attachment loss, pocket depths, bleeding, the extent and severity index as well as the CPI. This paper reports on the prevalence of maximum CPI values which is in accordance with the WHO reporting (WHO, 1997) and sets out the prevalences of CPI scores of 3 or 4 – i.e. moderate and severe periodontitis respectively. In 12-year-old children these scores are not required to be recorded by the WHO criteria. However, the majority of the children (70.0%) exhibited gingivitis. In the 15-year-old adolescents, 13.4% showed evidence of moderate to severe periodontitis (CPI scores 3 and 4). However, it is uncertain whether the cases with a maximum score of 3 (12.6%) reflect a form of periodontitis or conform to a specific anatomy of the gingiva in this age group (Jeffcoat and Reddy, 2000).

About three quarters of adult subjects have dental pockets; of these subjects, 52.7% exhibited at least one moderately deep and 20.5% one severely deep pocket. In senior citizens, at least one site with a dental pocket of 4 mm or more was commonly observed. With a prevalence of 87.8% (48.0% with a maximum score of 3 and 39.8% with a maximum score of 4), only one tenth of dentate senior citizens do not suffer from periodontitis. While there was no gender-related difference in severe CPI scores in adults, in senior citizens males are affected by this pathology significantly more frequently than females.

Comparison with the DMS III reveals a distinct increase in the higher maximum CPI scores. This is in contrast to trends regarding periodontitis in the United States (Borell *et al.*, 2005). In German adults, this is mainly related to the increase in the prevalence of a score of 3 (32.2% versus 52.7%) and to a lesser extent to the prevalence of a score of 4 (14.1% versus 20.5%). Although the prevalence of maximum CPI values does not necessarily reflect the extent and severity of the disease, it can be concluded that there is a need for improved measures to prevent periodontitis. In senior citizens, the increase in periodontitis compared with DMS III is mainly attributable to the increase in severe maximum pocket depths (24.4% versus 39.8%).

In general, the prevalence of moderate and severe periodontal conditions in German adults and senior citizens is high. This applies also, especially for the senior citizens, when comparing with internationally reported figures (WHO, 2007b). These high prevalences point to the need to encourage professional as well as self care preventive measures, such as improved oral hygiene, in males in particular. However, it should be noted that the reported figures reflect the percentage of subjects with maximum CPI scores of 3 (pocket depth 4–5 mm) and 4 (pocket depth \geq 6 mm) which includes subjects with only one such site.

With regard to tooth loss among the adult population, the study found that the average number of missing teeth in the adult cohort was 2.7 and among senior citizens 14.2. The corresponding averages documented by the DMS III in 1997 were 4.2 and 17.6 teeth respectively missing from the natural dentition (Institut der Deutschen Zahnärzte, 1999). Hence the number of teeth present increased for the first time in both adults and senior citizens.

Some 48.5% of missing teeth in the adult cohort and 88.7% of those in the senior citizens' cohort had been replaced with prostheses. This is comparable to data discussed by Zitzmann *et al.* (2007). Analysis of the type and extent of dental restorations showed that fixed prostheses predominated among adults, while removable forms were more common in senior citizens. Compared with the earlier study from 1997, the number of subjects with complete denture prostheses in at least one jaw was found to have fallen considerably in the senior citizens' group, from 44.2% to 30.5%. This is in accordance with trends in other European countries (Mojon *et al.*, 2004; Österberg *et al.*, 2006; Suominen-Taipale *et al.*, 1999). Total edentulousness was observed in 1.0% of the members of the adult cohort and in 22.6% of the senior citizens. In the latter group this constitutes a reduction from 24.8% in 1997. A similar decline in edentulism has been reported from the United States (Douglass *et al.*, 2002). However, edentulism is, like in other countries (Cunha-Cruz *et al.*, 2007; Suominen-Taipale *et al.*, 1999), a finding considerably influenced by socio-economic conditions.

Goals for oral health in Germany in the year 2020 have been set (Ziller *et al.*, 2006). The study indicates a clear trend towards achieving these goals with respect to caries experience and edentulousness. In all age groups, better oral health was correlated with improved self-care and improved recourse to professional dental help (Institut der Deutschen Zahnärzte, 2006). This is in accordance

with the increasing oral health status which has been shown in Sweden over a period of 30 years (Hugoson *et al.*, 2005). Our survey revealed high tooth-cleaning frequencies in all four age cohorts, with on average 74.2% of the children, 73.4% of the adolescents, 72.8% of the adults and 60.6% of the senior citizens reporting that they cleaned their teeth twice a day. Besides the use of a toothbrush (manual or electric) and toothpaste, the main additional products employed for this purpose were mouth rinsing solutions and, in some cases (especially in the adult cohort), dental floss.

According to the respondents, regular visits to the dentist for check-ups were a prominent element of their efforts in the field of oral health care (Institut der Deutschen Zahnärzte, 2006). Of those responding to the questionnaire, 76.0% of the children, 66.2% of the adolescents, 76.1% of the adults and 72.2% of the senior citizens reported that they went to the dentist regularly at least once a year for a check-up. These figures help to explain the reduction in caries experience (Krustrup and Petersen, 2006).

The higher number of periodontally affected teeth is no doubt correlated with the reduced number of extracted teeth. A detailed analysis shows that the extent and severity of clinical attachment loss in adults and senior citizens is not statistically different from the values recorded previously, but that the upper 20th percentile of the mean attachment loss (Locker and Leake, 1993) have increased considerably. This indicates that some of the teeth now remaining in the oral cavity exhibit periodontal destruction.

Conclusion

In conclusion, the study documents a distinct improvement in oral health in terms of caries, numbers of missing teeth, edentulousness and full upper and lower denture in all age groups over a period of eight years. On the other hand, an increasing prevalence of moderate and severe findings was recorded in periodontal conditions. The two trends are interrelated, as some of the intraorally remaining teeth exhibit periodontal pockets. The considerable improvements can be related to regular recourse to dental care services, better oral hygiene performance and, in children and adolescents, increased numbers of sealed fissures.

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