

# Caries prevalence in 12-year-old children from Germany. Results of the 2004 national survey

Andreas G. Schulte<sup>1</sup>, Anahita Momeni<sup>2</sup> and Klaus Pieper<sup>2</sup>

<sup>1</sup>Department of Conservative Dentistry, University of Heidelberg, Germany; <sup>2</sup>Department of Pediatric and Community Dentistry, Philipps-University Marburg, Germany

**Objective:** To determine the prevalence of dental caries in 12-year-old children in all 16 German Federal States in 2004 as part of a longitudinal observation project. **Design:** A cross-sectional oral health survey of children 12 years of age was performed in 2004. **Subjects:** After random selection 43,950 children were examined in schools. **Method:** DMFT and fissure sealants were recorded following WHO criteria. Caries was diagnosed at the caries into dentine threshold (D3) using the visual method without radiography or fibre-optic transillumination. **Results:** The proportion of children with caries experience was 39.3% throughout Germany. The mean DMFT score was 0.98 and the average Significant Caries Index (SiC) was 2.72. Compared to the results obtained in 2000, caries prevalence and caries experience decreased in this age group. As in 2000, all these specific results showed a wide variation among the different federal states, i.e., mean regional DMFT values between 0.71 and 1.42 were found and the mean number of fissure sealed teeth ranged between 1.9 and 3.4. **Conclusion:** The decrease in caries prevalence observed between 1994 and 2000 continued between 2000 and 2004, although once again considerable inequalities in oral health between the various federal states were observed.

**Key words:** caries prevalence, dental caries, national surveys, oral epidemiology, oral health, Significant Caries Index

## Introduction

During the decades many reports about a decreasing caries prevalence in European countries have been presented. Nevertheless, the number of publications presenting results of regularly repeated cross-sectional caries epidemiological studies is low. Until recently they were performed mainly in the following European countries: Germany, Ireland, Netherlands, Norway, Portugal, United Kingdom and Switzerland (Haugejorden and Birkeland 2002, Almeida et al. 2003, Menghini et al. 2003, Pieper and Schulte 2004, Truin et al. 2005, Pitts et al. 2006, Whelton et al 2006).

In 1989, Germany decided that caries prevention should be carried out in schools, and that its success be evaluated at regular intervals (German Social Security Code V). This evaluation was intended to consist in cross-sectional caries epidemiological examinations among different age groups. The results of the examinations performed on 12-year-old children in 1994-95, 1997 and 2000 have already been reported (Pieper and Schulte 2004). Caries prevalence was found to have declined during this period, from 68.9 % to 44.7 %. The mean DMFT score also decreased, from 2.6 to 1.2. The objective of this report is to present the results of the investigations of caries prevalence among 12-year-olds conducted in all German federal states in 2004.

## Materials and Methods

In 2004, the population of Germany was 82.5 million. There was no water fluoridation and the vast majority

of drinking water supplies throughout the country had low fluoride levels (<0.3 ppm). Since 1991, it has been legal to sell fluoridated domestic salt containing 250 ppm fluoride (Schulte 2005).

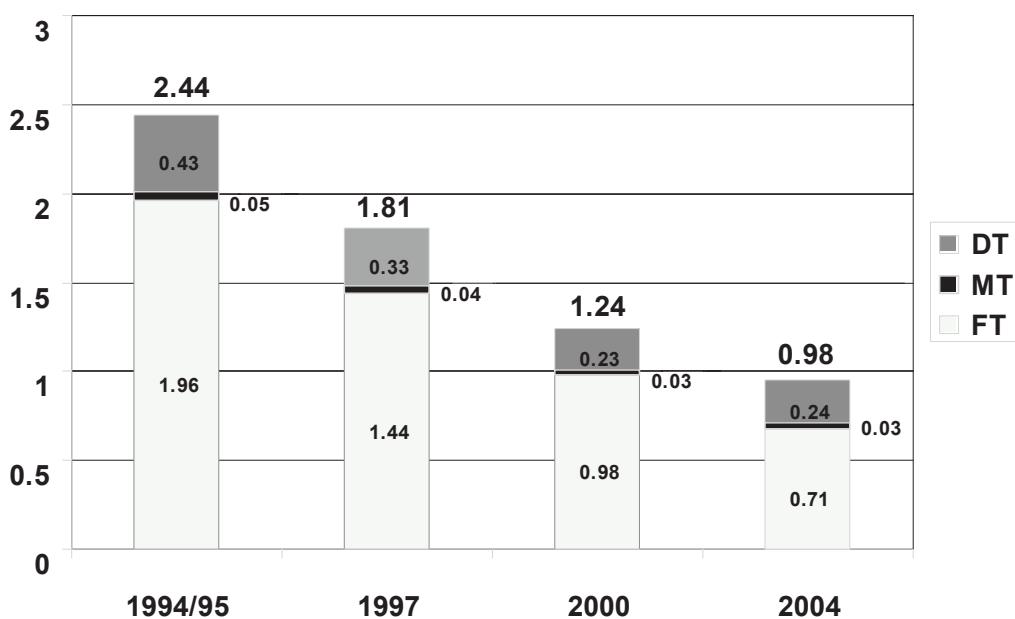
The 2004 study was the first to cover all sixteen German states (Figure 1), four more than in 1997. The states whose data were included for the first time are Bayern, Niedersachsen, Saarland and Sachsen. Furthermore and contrary to our report about the time span 1994 to 2000 (Pieper and Schulte 2004), this paper also includes the data for Brandenburg where the study did not start in 1994 but in 1997.

Bremen, Hamburg and Berlin are so-called city-states which do not include any surrounding countryside. Nordrhein-Westfalen, the most populous state, has a population of 18 million and consists of two regions ("Nordrhein" and "Westfalen-Lippe"), which are separate organisational units also in terms of preventive dentistry.

As in previous cross-sectional examinations (Pieper and Schulte 2004), in 2004 the sample of the 12-year-old children to be examined in each state was 5%. There were only two exceptions. In Bayern, a special representative sample of the population in question was made which covered 2% of the basic population. This was due to the fact that Bayern is the only German state which does not employ public health dentists. In Sachsen, no random sample was made, but rather the basic population of 12-year-olds was examined because the health authorities refused to perform a sample based examination apart from the census examination which is carried out in that state every year. The samples were selected by a two-stage random sampling procedure. The



**Figure 1.** German map showing the different federal states following reunification in 1990.



**Figure 2.** Mean DMFT scores in 12-year-old children in Germany 1994 – 2004. The values for 1994, 1997 and 2000 are based on 11 states and the values for 2004 are based on 16 states.

sampling frame was the roster of schools and school districts maintained by the departments of statistics. This roster consists of printed files of all public and private schools which list the range of grades and number of students enrolled.

Only children who were in their thirteenth year of life were included. In the states where the cross-sectional study had been performed before, the same schools were included. The schools were selected in the same way as in the previous surveys. However, the selection of schools in Bremen was adjusted to account for major socio-economic changes.

The samples were somewhat smaller in some states because organisational problems prevented certain districts from taking part in the respective examinations. Since the population figures in the various states showed considerable differences (between 6,311 children aged 12 years in the smallest state, Bremen, and 141,732 children in this age group in Bayern), the average figures of the individual states (DMFT, SiC, prevalence of fissure sealants) were weighted in the course of calculation according to the number of their 12-year-olds.

The examinations in the schools were conducted by specially trained public health dentists employed by the communities. Depending on the size of the state, the number of examiners in the study ranged between three and forty. Nearly all of these had been able to participate in at least one of the preceding three cross-sectional investigations. In Hamburg and in Bayern, special teams from the local university dental clinic performed the examinations. Standardised criteria were used to diagnose dental caries (World Health Organisation 1987). Dental caries was detected at the D3 caries into dentine threshold. In addition, teeth exhibiting fissure sealants, whether complete or incomplete, were also recorded. The dental examinations were performed with the use of artificial light, plane dental mirrors and dental explorers. No radiographs were taken.

As in the three previous cross-sectional surveys, all examiners in each state were trained by an experienced dentist before the 2004 study began. This included theoretical information, preliminary diagnostic training with slides and examinations of patients. This was followed by practical training in which a sample of 12-year-old children was examined by each of the study examiners, and the diagnoses compared to those recorded by the reference examiner. The calculation of inter-examiner agreement yielded a mean kappa value of 0.85.

The Statistical Package for Social Sciences (SPSS) was used for statistical analysis. Mean values and 95% confidence intervals were computed.

The examinations involved in this study were based on a national law (§21 of the German Social Security Code V). This is why it was not necessary to obtain permission from an ethics commission. The informed consent of the parents was not obtained because the volume of the examinations did not exceed the usual number of yearly examinations in schools. The community dentists conducted the work in the course of performing their official duties.

## Results

A total of 43,950 children 12 years of age were examined.

For all Germany, the proportion of caries-free (DMFT=0) 12-year-olds was calculated to be 60.7%. The national mean DMFT score was 0.98. Compared to the last of the three previous cross-sectional studies, this result represents a 21% decrease in mean caries experience (Figure 2). The average SiC index for Germany was 2.72.

The average nationwide care index (dental treatment expressed by FMT/DMFTx100) was 75.5%.

Table 1 shows the sample size and the mean age of the children examined in the different German federal

**Table 1.** Sample sizes, mean ages, proportion of children with teeth without dentine caries experience in permanent teeth and percentage of children with at least one fissure sealed tooth by federal state in 2004.

State	n	Age	% with DMFT=0	% sealed
Schleswig-Holstein	1313	12.5	61.0	58.2
Bremen	431	12.5	59.5	69.2
Hamburg	373	12.5	61.4	56.1
Niedersachsen	2428	12.5	62.2	61.7
Nordrhein	4563	12.5	64.0	64.6
Westfalen-Lippe	4972	12.5	59.2	64.2
Hessen	2545	12.5	62.4	70.8
Rheinland-Pfalz	2363	12.5	58.1	67.7
Saarland	571	12.5	68.3	66.0
Baden-Württemberg	1906	12.5	68.6	77.5
Bayern	1667	12.5	54.8	74.6
Mecklenburg-Vorpommern	1616	12.5	50.9	62.7
Berlin	1712	12.5	60.0	65.5
Brandenburg	1142	12.5	54.2	66.3
Sachsen-Anhalt	1081	12.5	53.8	68.3
Thüringen	606	12.6	53.3	63.5
Sachsen	14661	/	59.6	66.3

states. The proportion of children having permanent dentition without detectable caries experience ("caries-free") ranged between 50.9% and 68.6%.

Mean DMFT scores of between 0.71 and 1.42 were found in the different German federal states (Table 2). As far as data are available mean DMFT scores decreased in all states since 2000 (Table 3). Moreover, the care index varied considerably among the federal states, from a figure of 61% at the lowest to 83% at the highest (Table 2). The same observation was made with regard to the SiC (Table 4).

As in 2000, the majority of the children in all federal states had at least one fissure sealed tooth (Table 1). Depending on the state, the proportion of such children ranged between 58.2% and 77.5%. Figures for the mean number of fissure sealed teeth were found to be between 1.9 and 3.4 (Table 5).

## Discussion

Although national epidemiological surveys had been required by law as early as 1989, it was not until 2004 that all 16 federal states could be included in the relevant studies. Germany's federal structure and the extensive autonomy of government offices and facilities in the various states, as well as the German reunification in 1990, prevented these caries epidemiological studies from being conducted under the same conditions in all federal states. This was the reason why in two states the selected sample size differed from that applied in the other 14 states. Although in Bayern 2%, instead of 5% of the 12-year-olds were selected the number of the children examined was still very high (Table 1) thus providing a reliable data basis.

In 2004, the average DMFT score among 12-year-olds in Germany, based on all 16 federal states, was

**Table 2.** Mean DMFT scores and their components as well as care index (FT+MT/DMFT x 100) in 2004. Results by federal state.

State	DMFT	DT	MT	FT	% Care Index
Schleswig-Holstein	0.93	0.18	0.03	0.72	80.4
Bremen	0.98	0.37	0.03	0.57	61.0
Hamburg	0.88	0.27	0.01	0.61	70.1
Niedersachsen	0.91	0.25	0.02	0.64	72.5
Nordrhein	0.87	0.25	0.03	0.58	70.6
Westfalen-Lippe	1.07	0.35	0.03	0.69	67.7
Hessen	0.89	0.18	0.02	0.69	80.3
Rheinland-Pfalz	1.04	0.20	0.02	0.81	80.5
Saarland	0.71	0.23	0.01	0.46	75.8
Baden-Württemberg	0.71	0.19	0.01	0.51	72.9
Bayern	1.20	0.47	0.01	0.71	60.8
Mecklenburg-Vorpommern	1.42	0.21	0.04	1.17	85.5
Berlin	1.01	0.30	0.04	0.67	70.5
Brandenburg	1.17	0.20	0.05	0.95	83.0
Sachsen-Anhalt	1.26	0.23	0.06	0.97	81.8
Thüringen	1.18	0.27	0.04	0.87	77.2
Sachsen	1.03	0.18	0.03	0.82	82.5

**Table 3.** Mean DMFT scores in 12-year-olds living in different German federal states (1994-2004). CI denotes 95% confidence interval.

DMFT State	mean 1994/	mean 1997	mean 2000	CI 2000	mean 2004	CI 2004
Schleswig-Holstein	2.40	1.77	1.30	1.20-1.40	0.93	0.86-1.03
Bremen	2.10	1.31	1.29	1.07-1.46	0.98	0.82-1.12
Hamburg	2.35	2.04	1.37	1.18-1.58	0.88	0.74-1.03
Niedersachsen	/	/	1.16	1.08-1.23	0.91	0.85-0.97
Nordrhein	2.32	1.79	1.16	1.13-1.25	0.87	0.82-0.91
Westfalen-Lippe	2.20	1.66	1.19	1.13-1.25	1.07	1.04-1.13
Hessen	2.42	1.67	1.08	1.01-1.15	0.89	0.84-0.96
Rheinland-Pfalz	2.58	1.79	1.22	1.13-1.31	1.04	0.98-1.11
Saarland	/	/	/	/	0.71	0.59-0.82
Baden-Württemberg	2.42	1.43	1.03	0.95-1.11	0.71	0.65-0.77
Bayern	/	/	/	/	1.20	1.11-1.29
Mecklenburg-Vorpommern	3.54	2.79	1.95	1.90-2.09	1.42	1.22-1.51
Berlin	2.61	2.12	1.25	1.17-1.33	1.01	0.93-1.09
Brandenburg	/	2.04	1.40	1.26-1.45	1.17	1.07-1.28
Sachsen-Anhalt	2.61	2.41	1.68	1.58-1.77	1.26	1.14-1.38
Thüringen	2.60	1.96	1.42	1.29-1.50	1.18	1.04-1.32
Sachsen	/	/	/	/	1.03	1.00-1.06

**Table 4.** Development of SiC Index in 12-year-olds living in different German federal states (1994-2004).

<i>SiC</i> <i>State</i>	1994/95	1997	2000	2004
Schleswig-Holstein	5.15	4.34	3.42	2.63
Bremen	4.95	3.630	3.37	2.72
Hamburg	5.44	4.88	3.62	2.50
Niedersachsen	/	/	3.10	2.63
Nordrhein	5.18	4.35	3.20	2.52
Westfalen-Lippe	4.88	4.08	3.28	2.99
Hessen	5.19	4.16	3.01	2.55
Rheinland-Pfalz	5.59	4.42	3.34	2.87
Saarland	/	/	/	2.12
Baden-Württemberg	5.31	3.79	2.90	2.13
Bayern	/	/	/	3.29
Mecklenburg-Vorpommern	6.41	5.53	3.82	3.77
Berlin	5.41	4.93	3.40	2.83
Brandenburg	/	4.47	3.74	3.15
Sachsen-Anhalt	5.27	5.07	4.06	3.40
Thüringen	5.16	4.39	3.70	3.14
Sachsen	/	/	/	2.85

**Table 5.** Development of mean number of fissure sealed teeth in 12-year-olds living in different German federal states (1997-2004).

<i>Fissure sealed teeth</i> <i>State</i>	mean 1997	mean 2000	mean 2004
Schleswig-Holstein	0.20	2.13	2.8
Bremen	0.50	2.48	2.7
Hamburg	1.30	2.26	1.9
Niedersachsen	/	/	2.6
Nordrhein	0.40	2.15	2.5
Westfalen-Lippe	1.30	2.28	2.5
Hessen	1.10	2.31	2.8
Rheinland-Pfalz	1.50	2.22	2.5
Saarland	/	/	2.4
Baden-Württemberg	2.00	2.83	3.2
Bayern	/	/	3.4
Mecklenburg-Vorpommern	0.20	2.22	2.3
Berlin	1.40	2.60	2.4
Brandenburg	/	/	2.3
Sachsen-Anhalt	1.00	2.19	2.5
Thüringen	0.30	2.70	2.3
Sachsen	/	/	2.4

0.98. If we calculate the DMFT for the 11 states already included in the earlier studies, we come up with a value of 0.95. These calculations show that including the additional federal states made little difference in the national DMFT score.

Compared with other national surveys, the actual level of dental caries experience in German 12-year-old children is about the same as in the United Kingdom and in the Republic of Ireland (Pitts et al. 2006, Whelton et al. 2006). Mean DMFT values of 0.98 and 1.1 for Germany and the United Kingdom respectively places these countries in the one third of European countries with the lowest caries experience.

Comparing the data from 2000 and 2004 showed that there was a substantial decline in both caries prevalence and caries experience (Fig. 2), thus continuing the development that has been documented in Germany since 1994 (Pieper and Schulte 2004).

In 2000, the mean proportion of 12-year-old children with caries experience in Germany was 44.7% (Pieper and Schulte 2004), below 50% for the first time. However, this did not hold for every federal state. The average proportion of children with caries experience in 2004 was only 39.3%. For the first time since these examinations started ten years previously, a caries prevalence of less than 50% was found in all federal states (Table 1). This is remarkable in as much as now more than half of all 12-year-old children had caries-free dentition even in federal states with above-average levels of unemployment. It is also gratifying that the gap between the various states seems to be closing as far as caries prevalence is concerned. While the difference between the state with the highest and that with the lowest number of children with caries experience was 22.0 percentage points in 2000 (Pieper and Schulte 2004), the corresponding value was only 17.7 in 2004 (Table 1).

The decline in the mean DMFT score from 1.24 (2000) to 0.98 (2004) corresponds to a reduction of caries experience in Germany of 20.9% in a period of four years. The decline was observed in all federal states and can be considered to be statistically significant because the corresponding confidence intervals of the years 2000 and 2004 do not overlap (Table 3). On average this corresponds to a decrease by 5.2% per year. Compared to the previous observation periods (1994 to 1997 and 1997 to 2000) where average annual reductions of 8.6% and 10.5% respectively had been observed, this indicates that the rate of caries decline has slowed down (Pieper and Schulte 2004).

A similar development was also reported from the United Kingdom (Pitts et al. 2006). Studies from the Netherlands, France, Norway and Switzerland show that the caries prevalence reached a plateau after a long period of decrease (Haugejorden and Birkeland 2002, Menghini et al. 2003, Truin et al. 2005, Tramini 2005). Nevertheless, in these countries the level of plateau differs distinctly. In recent years caries prevalence was about 50% in Norway, 40% in Switzerland (Canton Zurich) and 20% in the Netherlands (The Hague). Caries decline in Germany is expected to continue in the future due to ongoing caries prevention efforts. Different reasons are considered to be responsible for a halt in caries decline. In France, sales of fluoridated salt declined considerably and in Norway an increase in total sugar consumption and changing patterns of sugar intake were observed (Haugejorden and Birkeland 2002, Tramini 2005).

The SiC was introduced in order to focus attention on those with high levels of caries (Bratthall 2000). The target value mentioned by Bratthall (2000) was 3.0, which 12-year-olds should reach by 2015 at the latest. At the national level, in Germany the SiC index dropped from 3.30 in 2000 to 2.72 in 2004. This means that there was still a distinct decline in caries even in the group of children with the highest caries experience. However, this development was somewhat less marked, at 15.8%, than in the overall group of 12-year-olds. Nevertheless, across the states a wide variation in caries experience was not only seen in these children with a high caries experience but in the whole sample as well (Table 3 and Table 4). A similar observation was also made in England and Wales (Pitts et al. 2002).

The important role of fissure sealants and other possible reasons for the decline in caries experience in Germany have already been extensively discussed in a previous publication (Pieper and Schulte 2004). One of the most visible changes in caries prevention between 2000 and 2004 was the growth in the market share of fluoridated salt from 41% to 61 % (Schulte 2005). Furthermore, the number of fissure sealants increased slightly as well (Table 5).

Despite these accomplishments, further efforts must be made in the area of caries prevention in the coming years. Among other things, for instance, the fact that children from low socio-economic classes receive distinctly fewer fissure sealants than children from the middle and upper classes must be given more attention (Klemme et al. 2004). Suggestions in this regard have

included such steps as not only sealing fissures in dentists' offices, as has been common in Germany until now, but also in schools attended by large numbers of lower class children (Klemme et al. 2004).

An overriding goal of all persons and institutions involved in caries prevention should be not only to reduce the mean caries prevalence, but also to eliminate the regional differences in caries prevalence, which are still pronounced.

## Acknowledgements

We would like to thank the Deutsche Arbeitsgemeinschaft für Jugendzahnpflege (DAJ) for providing the financial support to perform this study. We are particularly grateful to all the community dentists who diligently reported the epidemiological data used in this study.

## References

- Almeida, C.M., Petersen, P.E., André, S.J., Toscano, A. (2003): Changing oral health status of 6- and 12-year-old children in Portugal. *Community Dental Health* **20**, 211-216.
- Bratthall, D. (2000): Introducing the Significant Caries Index together with a new global oral health goal for 12-year-olds. *International Dental Journal* **50**; 378-384.
- Haugejorden, O., Birkeland, J.M. (2002): Evidence for reversal of the caries decline among Norwegian children. *International Journal of Pediatric Dentistry* **12**; 306-315.
- Klemme, B., Tramini, P., Niekusch, U., Rossbach, R., Schulte, A.G. (2004): The relationship between caries prevalence and fissure sealants among 12-year children at three educational strata. *Sozial- und Präventivmedizin* **49**, 344-351
- Menghini, G., Steiner, M., Marthaler, T.M., Helfenstein, U., Brodowski, D., Imfeld, C., Weber, R., Imfeld T. (2003): Caries prevalence in schoolchildren of 16 communities in the Canton of Zurich from 1992 to 2000 (in German). *Schweiz Monatsschr Zahnmed* **113**, 267-277.
- Pieper, K., Schulte, A.G. (2004): The decline in dental caries among 12-year-old children in Germany between 1994 and 2000. *Community Dental Health* **21**, 199-206.
- Pitts, N.B., Evans, D.J., Nugen, Z.J., Pine, C.M. (2002): The dental caries experience of 12-year-old children in England and Wales. Surveys coordinated by the British Association for the Study of Community Dentistry in 2000/2001. *Community Dental Health* **19**, 46-53.
- Pitts, N.B., Chestnutt, G., Evans, D., White, D., Chadwick, B., Steele, J.G. (2006). The dentinal caries experience of children in the United Kingdom, 2003. *British Dental Journal*, **200**, 313-320.
- Schulte, A.G. (2005): Salt fluoridation in Germany since 1991. *Schweizer Monatsschrift Zahnmedizin* **115**, 659-662.
- Tramini, P. (2005): Salt fluoridation in France since 1986. *Schweizer Monatsschrift Zahnmedizin* **115**, 656-658.
- Truin, P., van Rijkom, H.M., Mulder, J., van't Hof, M.A. (2005): Caries trends 1996-2002 among 6- and 12-year-old children and erosive wear prevalence among 12-year-old children in The Hague. *Caries Research* **39**, 2-8.
- Whelton, H., Crowley, E., O'Mullane, D., Donaldson, M., Cronin, M., Kelleher, V. (2006). Dental caries and enamel fluorosis among the fluoridated population in the Republic of Ireland and non fluoridated population in Northern Ireland in 2002. *Community Dental Health* **23**, 37-43.
- World Health Organization (1987). Oral Health Surveys: Basic Methods. 3rd. ed., Geneva: WHO.