

Caries prevalence in 12-year-old children from Germany: Results of the 2009 national survey

K. Pieper¹, J. Lange¹, A. Jablonski-Momeni¹ and A.G. Schulte²

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

Objective: In 2009, complementary epidemiological studies were conducted in 16 German states. **Design:** A 2009 cross-sectional oral health survey of children aged 12 years with 5% samples selected using a two-stage random sampling procedure. **Subjects:** A random selection of 30,943 12-year-olds 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. Statistical evaluation was performed using the software SPSS (v12.0). **Results:** The proportion of children across Germany with caries experience was 31%. The mean DMFT score was 0.72 and the average Significant Caries Index (SiC) was 2.29. The results showed a wide variation among the different federal states, with mean regional DMFT values ranging from 0.56 to 1.06. Compared to the results obtained in 2004, caries prevalence and caries experience decreased distinctly in this age group. The mean DMFT score for 12-year-olds dropped from 2.44 to 0.72 between 1994 and 2009. The mean DMFT scores were 72.7% lower at the end of the observation period than a few years after the introduction of extensive caries prevention measures in Germany. The mean number of fissure sealed teeth ranged between 2.24 and 3.04. **Conclusion:** The decrease in caries prevalence observed between 1994 and 2004 continued between 2004 and 2009, although once again inequalities in oral health between federal states were observed.

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

Introduction

In 1989 Germany decided that caries prevention should be carried out in schools, and its success evaluated at regular intervals (German Social Security Code V). This evaluation was intended to consist of cross-sectional caries epidemiological examinations among different age groups. The results of the examinations performed on 12-year-olds in 1994–95, 1997, 2000 and 2004 have already been reported (Pieper and Schulte, 2004; Schulte *et al.*, 2006). Caries prevalence was found to have declined during this period, from 68.9% to 39.3% while mean DMFT scores decreased, from 2.6 to 1.0. The objective of this report is to present the results of the investigations of caries prevalence among 12-year-olds conducted across all German federal states in 2009 and discuss them in relation to the other investigations in the series of national surveys.

Materials and Methods

In 2009, the population of Germany was 81.9 million. The 2004 study was the first to cover all 16 German states, five more than in 1997 (Schulte *et al.*, 2006). Bremen, Hamburg and Berlin are so-called city-states which do not include any surrounding countryside. North Rhine-Westphalia, the most populous state, has 18 million inhabitants and consists of two regions (Northern Rhineland and Westphalia-Lippe), which are also separate organisational units in terms of preventive dentistry.

As in previous examinations conducted in this longitudinal series, observing caries prevalence among 12-year-olds, the goal in 2009 was to examine 5% of this age group. An exception here was Bavaria, where a special representative sample of the population was drawn which covered 2% of the total population. In Saxony, no random sample was made, but rather the basic population of 12-year-olds was examined.

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. Other schools were selected in the same way as in the preceding 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 12-year-olds in Bremen and 141,732 in Bavaria), the average figures for the individual states (DMFT, SiC, prevalence of fissure sealants) were weighted in the analysis 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 partici-

pate in at least one of the preceding four cross-sectional investigations. In Hamburg, a special team from the local university dental clinic performed the examinations. Standardised criteria oriented toward WHO specifications were used to diagnose dental caries (World Health Organization, 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 children brushed their teeth before the evaluation took place. The dental examinations were performed with the use of artificial light, plane dental mirrors and dental explorers with sharp tips. No air drying was applied. Detection and assessment of the carious lesions were mainly based on visual examination. During the calibration courses the examiners were trained to probe gently when using the 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 2009 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-olds was examined by each of the study examiners, and the diagnoses compared to those recorded by the reference examiner. The calculation of reproducibility yielded a mean kappa value of 0.85. The following outcome variables were calculated: DMFT, SiC, % caries free, caries prevalence, “care index”, mean number of fissure sealed teeth. Using SPSS v20.0 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. In the federal states involved in our study, parents are obliged to accept examinations of this nature.

Results

A total of 30,943 children aged 12 were examined. The national mean DMFT score was 0.72 (Figure 1). Compared to the first national survey carried out in 1994 the mean DMFT was 72.7% lower in 2009. In 2009 the average SiC index for German 12-year-olds was 2.29 and 69% were caries-free. Thus the caries prevalence in this age group was 31%. The average nationwide care index ($FMT \div DMFT \times 100$) was 74.6%.

Table 1 shows the sample sizes and the average ages of the children examined in the different German federal states. The proportion of children having permanent dentition without detectable caries experience (“caries-free”) ranged between 60.4% and 82.4%.

Most children in each federal state had at least one fissure sealed tooth and the proportion of such children ranged between 63.5% and 74.1% (Table 1). Mean DMFT scores between 0.29 and 1.06 were found in the different states (Table 2). Moreover, the care index varied considerably among the states, from 46% to 86%. The same

observation was made with regard to the SiC (Table 3). As far as data are available, mean DMFT scores have decreased in all states since 2000 (Table 4).

The average nationwide number of fissure sealed teeth was 2.46 with the mean number of fissure sealed teeth varying between 2.24 and 3.04 (Table 5).

Discussion

In 2009, the average DMFT score among 12-year-olds in Germany, based on all 16 federal states, amounted to 0.72. Compared with previous investigations in the series of national surveys, the trend of caries decline among 12-year-olds continued.

The mean DMFT scores in nearly all federal states were below 1 (Table 2) and dental health had improved in all states. The lowest DMFT-values were observed in Baden-Württemberg and Saarland (means 0.56 and 0.29), whereas the states with the highest values were Mecklenburg-Vorpommern and Bayern (mean DMFT: 0.98 and 1.06). The WHO has defined categories of caries prevalence to classify various states with regard to dental health (World Health Organization, 1984). A low caries prevalence is present when the mean DMFT scores are between 1.2 and 2.6; <1.2 indicates a very low caries prevalence. As the national survey performed in Germany in 2009 shows, caries prevalence in all federal states can be classified in the very low category. The goal of the Bundeszahnärztekammer (German Dental Association) for 2020 (DMFT<1) was already reached in 2009 in nearly all federal states (Österreich and Ziller, 2005).

Comparing the data from 2004 and 2009 showed that there was a substantial decline in both caries prevalence and caries experience, thus continuing the progress documented in Germany since 1994 (Schulte *et al.*, 2006).

In 2004, the mean proportion of 12-year-olds with caries experience in Germany was 39.3% (Schulte *et al.*, 2006), below 50% for the first time. However, this did not hold for every federal state. The average proportion

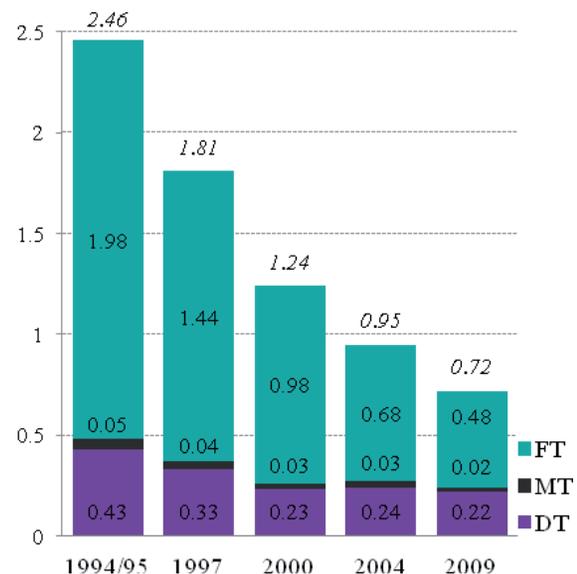


Figure 1. Mean DMFT scores in 12-year-olds in Germany 1994–2009

Table 1. Sample sizes, mean ages, proportion of children without caries experience in permanent teeth and percentage of children with at least one fissure sealed tooth by federal state in 2009

<i>State</i>	<i>n</i>	<i>Age (years)</i>	<i>% with DMFT=0</i>	<i>% sealed</i>
Schleswig-Holstein	1286	12.4	70.4	66.4
Bremen	280	12.5	62.5	---
Hamburg	335	---	69.9	---
Niedersachsen	1612	12.5	72.2	67.4
Nordrhein	4806	12.5	72.6	67.0
Westfalen-Lippe	4925	12.5	68.6	68.1
Hessen	3466	12.5	73.4	70.8
Rheinland-Pfalz	2324	12.5	70.0	70.3
Saarland	210	12.4	82.4	70.5
Baden-Württemberg	1071	---	72.2	---
Bayern	1727	12.5	62.3	74.1
Mecklenburg-Vorpommern	1481	12.5	60.4	64.6
Berlin	1831	12.5	63.6	68.7
Brandenburg	1657	12.4	64.9	68.2
Sachsen-Anhalt	1352	12.4	67.4	68.9
Thüringen	1052	12.5	63.5	63.5
Sachsen	1528	---	71.9	---

“---” denotes no data available for the year of examination

Table 2. Mean values for DMFT score, its components and percentage care index (FT+MT/DMFT) in 2009 by federal state

<i>State</i>	<i>DMFT</i>	<i>DT</i>	<i>MT</i>	<i>FT</i>	<i>% Care Index</i>
Schleswig-Holstein	0.65	0.15	0.02	0.49	75.4
Bremen	0.84	0.19	0.00	0.65	77.4
Hamburg	0.69	0.12	0.02	0.55	79.7
Niedersachsen	0.62	0.14	0.01	0.47	75.8
Nordrhein	0.60	0.15	0.02	0.43	71.7
Westfalen-Lippe	0.70	0.16	0.03	0.51	72.9
Hessen	0.60	0.15	0.02	0.43	71.7
Rheinland-Pfalz	0.66	0.13	0.01	0.52	78.8
Saarland	0.29	0.04	0.00	0.25	86.2
Baden-Württemberg	0.56	0.16	0.01	0.39	69.7
Bayern	1.06	0.56	0.01	0.49	46.2
Mecklenburg-Vorpommern	0.98	0.14	0.02	0.82	83.7
Berlin	0.88	0.27	0.03	0.58	65.9
Brandenburg	0.83	0.13	0.03	0.66	79.6
Sachsen-Anhalt	0.76	0.16	0.02	0.57	75.0
Thüringen	0.83	0.17	0.04	0.63	75.9
Sachsen	0.65	0.09	0.02	0.54	83.1

of children with caries experience in 2009 was only 31%. For the first time since these examinations started fifteen years previously, a caries prevalence of less than 50% was found in all federal states (Table 1). This is remarkable inasmuch as now more than half of all 12-year-olds had caries-free dentition even in the northeastern federal states with above-average levels of unemployment such as Mecklenburg-Vorpommern and Sachsen-Anhalt. The decline in the mean DMFT score from 0.95 (2004) to 0.72 (2009) corresponds to a reduction of caries experience in Germany by 24% within a period of five 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 2004 and 2009 do not overlap (Table 4). This also indicates that

caries declined on average by 4.8% per year. Compared to the period from 2000 to 2004, where an average annual reduction of 5.2% had been observed, this means that the rate of caries decline slowed (Schulte *et al.*, 2006). A similar development was also reported from England and Wales (Davies *et al.*, 2012; Pitts *et al.*, 2002). Nonetheless, we do not expect this development to come to a standstill in Germany in the coming years. The example of the Netherlands shows that stagnation cannot be expected until the caries prevalence amounts to only about 20% (Truin *et al.*, 2005). However, observations from France indicate that caries prevalence can also stagnate, e.g. when sales of fluoridated salt decrease markedly (Tramini, 2005).

Fluoridated salt was introduced in Germany in 1991 and is sold in 500g packages as iodated salt with fluoride in all supermarkets. Within 10 years the market share of this salt increased to nearly 60% (Schulte 2005). Subsequently another increase was observed so that in 2005 for the first time the market share was very close to 70%, a value that has been stable since then. Unfortunately canteens, cafeterias and restaurants can use fluoridated salt only with a special permission which only a few German institutions, like the staff cafeteria of the Heidelberg University Medical and Dental School, have received to date (Schulte *et al.*, 2002).

Table 3. Significant Caries Index in 12-year-olds living in different German federal states (1994-2009)

State	Significant Caries Index				
	1994/95	1997	2000	2004	2009
Schleswig-Holstein	5.15	4.34	3.42	2.63	1.95
Bremen	4.95	3.63	3.37	2.72	2.41
Hamburg	5.44	4.88	3.62	2.50	2.05
Niedersachsen	---	---	3.10	2.63	1.87
Nordrhein	5.18	4.35	3.20	2.52	1.79
Westfalen-Lippe	4.88	4.08	3.28	2.99	2.09
Hessen	5.19	4.16	3.01	2.55	1.80
Rheinland-Pfalz	5.59	4.42	3.34	2.87	1.97
Saarland	---	---	---	2.12	---
Baden-Württemberg	5.31	3.79	2.90	2.13	1.68
Bayern	---	---	---	3.29	3.05
Mecklenburg-Vorpommern	6.41	5.53	3.82	3.77	2.75
Berlin	5.41	4.93	3.40	2.83	2.56
Brandenburg	---	4.47	3.74	3.15	2.43
Sachsen-Anhalt	5.27	5.07	4.06	3.40	2.28
Thüringen	5.16	4.39	3.70	3.14	2.39
Sachsen	---	---	---	2.85	1.78

“---” denotes the absence of data

The possible reasons for the decline in caries experience in Germany have already been extensively discussed in another publication (Pieper and Schulte, 2004). The SiC was introduced to enable caries experience to be differentiated within a single population group (Bratthall, 2000). The target value mentioned by Bratthall was 3.0, which 12-year-olds should reach by 2015 at the latest. At the national level, the SiC index dropped from 2.7 in 2004 to 2.2 in 2009. However, this target was not achieved by 2004 in the states of Bayern, Brandenburg, Mecklenburg-Vorpommern, Thüringen, Berlin and Bremen (Table 3). By 2009, nearly all states had achieved the target of under 3.0 for the SiC.

Various studies show that regular dental hygiene with fluoride toothpaste, fissure sealing of molars, topical fluoridation measures within the context of group and individual prevention, and the use of fluoridated table salt, as well as taking fluoride tablets, have substantially contributed to improving dental health in the past ten years (Momeni *et al.*, 2007; Pieper *et al.*, 2007; Schiffner and Reich, 1999; Schulte *et al.*, 2001).

The development of dental health among that third of young people who exhibit higher caries scores deserves more attention. Among 12-year-olds, mean DMFT values have improved in most German states by about 30% in the past five years. At the same time, the SiC values declined by about the same magnitude. In some federal states, however, DMFT scores and SiC values only dropped by 12-22%. This shows that in certain regions, preventive measures should focus more on young people with increased caries risk and, with the consent of parents, more fluoride varnishes, gels or solutions should be used in school programs. It has already been proven that selective intensified prevention (SIP) has a positive influence on oral health of 12-year-olds.

Klimek *et al.* (1992) investigated in Marburg whether there was a connection between the caries-preventing effect of a six-year Duraphat® application (twice a year) and

Table 4. Mean DMFT scores in 12-year-olds living in different German federal states (1994-2009)

State	1994/95	1997	2000		2004		2009	
	DMFT	DMFT	DMFT	95%CI	DMFT	95%CI	DMFT	95%CI
Schleswig-Holstein	2.40	1.77	1.30	1.20-1.40	0.93	0.86-1.03	0.65	0.58-0.72
Bremen	2.10	1.31	1.29	1.07-1.46	0.98	0.82-1.12	0.84	0.61-0.94
Hamburg	2.35	2.04	1.37	1.18-1.58	0.88	0.74-1.03	0.69	0.55-0.81
Niedersachsen	---	---	1.16	1.08-1.23	0.91	0.85-0.97	0.62	0.56-0.69
Nordrhein	2.32	1.79	1.16	1.13-1.25	0.87	0.82-0.91	0.60	0.56-0.63
Westfalen-Lippe	2.20	1.66	1.19	1.13-1.25	1.07	1.04-1.13	0.70	0.66-0.73
Hessen	2.42	1.67	1.08	1.01-1.15	0.89	0.84-0.96	0.59	0.56-0.64
Rheinland-Pfalz	2.58	1.79	1.22	1.13-1.31	1.04	0.98-1.11	0.66	0.61-0.71
Saarland	---	---	---	---	0.71	0.59-0.82	0.29	0.20-0.39
Baden-Württemberg	2.42	1.43	1.03	0.95-1.11	0.71	0.65-0.77	0.56	0.50-0.63
Bayern	---	---	---	---	1.20	1.11-1.29	1.06	0.97-1.15
Mecklenburg-Vorpommern	3.54	2.79	1.95	1.90-2.09	1.42	1.22-1.51	0.98	0.89-1.06
Berlin	2.61	2.12	1.25	1.17-1.33	1.01	0.93-1.09	0.88	0.81-0.95
Brandenburg	---	2.04	1.40	1.26-1.45	1.17	1.07-1.28	0.83	0.75-0.90
Sachsen-Anhalt	2.61	2.41	1.68	1.58-1.77	1.26	1.14-1.38	0.76	0.68-0.84
Thüringen	2.60	1.96	1.42	1.29-1.50	1.18	1.04-1.32	0.83	0.74-0.91
Sachsen	---	---	---	---	1.03	1.00-1.06	0.65	0.58-0.72

“---” denotes the absence of data

Table 5. Mean numbers of fissure sealed teeth in 12-year-olds living in different German federal states (2000-2009)

State	Mean number of fissure sealed teeth		
	2000	2004	2009
Schleswig-Holstein	2.13	2.16	2.55
Bremen	2.48	2.67	2.37
Hamburg	2.26	1.89	2.24
Niedersachsen	2.40	2.31	2.56
Nordrhein	2.15	2.48	2.81
Westfalen-Lippe	2.28	2.53	2.77
Hessen	2.31	2.80	3.04
Rheinland-Pfalz	2.22	2.47	2.74
Saarland	---	2.43	2.70
Baden-Württemberg	2.83	3.17	2.90
Bayern	---	3.02	3.02
Mecklenburg-Vorpommern	2.22	2.28	2.49
Berlin	2.60	2.44	2.53
Brandenburg	2.18	2.26	2.53
Sachsen-Anhalt	2.19	2.52	2.48
Thüringen	2.70	2.28	2.48
Sachsen	---	2.43	2.58

“---” denotes the absence of data

the caries experience of primary teeth at the beginning of the fluoride varnish program. The children receiving preventive treatment were divided into three caries risk groups (low/moderate/high) according to their dmft scores at the beginning of the observation period. As it turned out, the relative caries reduction was highest among children with a low caries risk (63% compared to the control group), but lowest among those with a high caries risk (25% compared to the control group). To counteract the polarisation of caries experience, basic prevention programs are expanded to include selective intensive prevention (SIP). In Marburg County for example two additional visits by the dental team each year are added to the basic prevention program (Pieper *et al.*, 2011). In addition nutritionists provide intensive nutritional counseling in the relevant third and fourth grade classes (two lessons of two hours each) in some regions. About 5% of the German regions are covered by such a program.

In summary SIP is offered at individual schools in underprivileged districts comprising the following measures: enhanced health education; oral hygiene instructions four times per year; and, fluoride varnish applications four times per year. Hence frequent use of Duraphat fluoride varnish (quarterly for six years) was as effective for children at increased risk of caries as a twice-a-year application for children from the “normal population” (Pieper *et al.*, 2011). In general, however, it can be said that not only children at low risk of caries, but also those at high-risk are profiting from the widespread decline in caries. While the SiC values among 12-year-olds were still between 4.88 and 6.41 in 1994-95, they fell to between 1.68 and 3.05 in the 2009 study.

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

References

- 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.
- Davies, G.M., Jones, C.M., Monaghan, N., Morgan, M.Z., Neville, J.S. and Pitts, N.B. (2012): The caries experience of 11 to 12 year-old children in Scotland and Wales and 12 year-olds in England in 2008-2009: reports of co-ordinated surveys using BASCD methodology. *Community Dental Health* **29**, 8-13.
- Klimek, J., Schmidt, S., Schmidt, H.F.M. and Jürgensen, R. (1992): [The caries-preventive effect of Duraphat to 6 years depending on the caries risk]. *Deutsche Zahnärztliche Zeitschrift* **47**, 761-763
- Momeni, A., Hartmann, T., Born, C., Heinzel-Gutenbrunner, M. and Pieper, K. (2007): Association of caries experience in adolescents with different preventive measures. *International Journal of Public Health* **52**, 393-401.
- Österreich, D. and Ziller, S. (2005): [Oral health goals for Germany up to the year 2020]. *Public Health Forum* **46**, 22-23.
- Pieper, K. and Schulte, A.G. (2004): The decline in dental caries among 12-year-old children in Germany between 1994 and 2000. *Community Dental Health* **21**, 207-211.
- Pieper, K., Born, C., Hartmann, T., Heinzel-Gutenbrunner, M. and Jablonski-Momeni, A. (2007): Association of preventive measures with caries experience expressed by outcome variables. *Schweizer Monatsschrift Zahnmedizin* **117**, 1038-1044.
- Pieper, K., Weber, K., Margraf-Stiksrud, J., Stein, S., Heinzel-Gutenbrunner, M. and Jablonski-Momeni, A. (2011): Evaluation of an intensified preventive programme aimed at 12-year-olds with increased caries risk. *Journal of Public Health* **2**, 151-157.
- Pitts, N.B., Evans, D.J., Nugent, Z.J. and 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.
- Schiffner, U. and Reich, E. (1999): Prävalenzen zu ausgewählten klinischen Variablen bei den Jugendlichen (12 Jahre). In: [Third German Oral Health Study (DMS III). Results, trends and analysis of problems based on representative population samples]. Institut der Deutschen Zahnärzte, pp201-230. Köln: Deutscher Ärzteverlag.
- Schulte, A.G., Gräber, R., Koch, M.J., Kasperk, C. and Staehle, H.J. (2002): Influence of fluoridated salt on urinary fluoride excretion of adults. *Caries Research* **36**, 391-397
- Schulte, A.G. (2005): Salt fluoridation in Germany since 1991. *Schweizer Monatsschrift Zahnmedizin* **115**, 659-662.
- Schulte, A.G., Momeni, A. and Pieper, K. (2006): Caries Prevalence in 12-year-old Children from Germany. Results of the 2004 national survey. *Community Dental Health* **23**, 197-202.
- Schulte, A.G., Rossbach, R. and Tramini, P. (2001): Association of caries experience in 12-year-old children in Heidelberg, Germany, and Montpellier, France, with different caries preventive measures. *Community Dentistry and Oral Epidemiology* **29**, 354-361.
- Tramini, P. (2005): Salt fluoridation in France since 1986. *Schweizer Monatsschrift Zahnmedizin* **115**, 656-658.
- Truin, P., van Rijkom, H.M., Mulder, J. and 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.
- World Health Organisation (1984): *Oral health global indicator for 2000*. Geneva: WHO.
- World Health Organization (1987): *Oral Health Surveys: Basic Methods*. 3rd. edn. Geneva: WHO.