Caries Prevalence in an Adult Population: Results of the Study of Health* in Pomerania, Germany (SHIP)

Ch. Splieth[a]/Ch. Schwahn[a]/O. Bernhardt[a]/T. Kocher[a]/G. Born[b]/U. John[b]/E. Hensel[a]

Purpose: The aim of this study was to assess the caries prevalence in the adult population of Pomerania, Germany in comparison to national and international data.

Materials and Methods: The study sample comprised 4,022 randomly selected subjects who were examined from October 1997 to May 2001 within the "Study of Health in Pomerania" (medical and dental, population-based cross-sectional study in Pomerania, Northeast Germany. Response rate: 69%. Age range of subjects: 25 – 79 yrs). Carious defects, fillings and missing teeth were diagnosed and the DMFT/S scores were calculated according to WHO guidelines (1997). These figures were compared to other German, Swedish and US data.

Results: Women exhibited higher mean DMFT and DMFS values in all age groups than men. The mean DMFT/S scores were slightly higher than the values for the only two available nationally representative age groups in Germany. The prevalence of primary carious lesions or secondary caries was very low, resulting in minor treatment needs (decayed surfaces: mean 0.95 ± 3.3) and high care indices (FS/DFS) for all age groups (90 – 95%). In contrast to this, the mean numbers of fillings in adults and especially of missing teeth in seniors were much higher in Pomerania for all age groups than in the Swedish and US adult population, where a caries decline was demonstrated.

Conclusion: In spite of a very low prevalence of primary carious lesions and secondary caries, the mean number DMFT/S and especially MT/S scores in the Pomeranian adult population are high in comparison with Swedish and US data, but differed only slightly from the limited available national data for Germany.

Key words: caries prevalence, DMFT, Germany, missing teeth, oral health

Oral Health Prev Dent 2003; 1: 149–155. Submitted for publication: 30.09.02; accepted for publication: 16.12.02.

[a] *Center of Oral Health, University of Greifswald, Germany.*

[b] *Institute of Epidemiology and Social Medicine, University of Greifswald, Germany.*

Reprint requests: *PD Dr. Ch. H. Splieth, Zentrum für Zahn-, Mund- und Kieferheilkunde, University of Greifswald, Rotgerberstraße 8,17487 Greifswald, Germany. E-mail: splieth@uni-greifswald.de*

** The work is part of the Community Medicine Research net (CMR) of the University of Greifswald, Germany, which is funded by the Federal Ministry of Education and Research (grant no. ZZ 9603), the Ministry of Cultural Affairs, and the Social Ministry of the Federal State of Mecklenburg-Vorpommern. The CMR encompasses several research projects, which share data of the population-based Study of Health in Pomerania. (SHIP: http://www.medizin.uni-greifswald.de/cm)*

Epidemiological data clearly demonstrate a marked caries decline in children and adolescents (Bratthall et al, 1996; Downer, 1991; Ainamo, 1987; Glass, 1982; NIDR, 1981). For the long-term evaluation of preventive dentistry, it is of major importance to determine whether this reduction in the prevalence of caries is maintained during adulthood. Caries data for adult populations are much rarer than for children. Swedish data from 1973 to 1993 detected a marked decrease in proximal carious lesions and fillings in 20 – 50-year-olds, but also an unchanging group of individuals with high caries prevalence (Hugoson et al, 2000; Hugoson et al, 1995). In seniors, a shift from missing teeth to re-

stored teeth was found, still leading to a small reduction of the mean DMFS score for this age group.

In the USA, national representative surveys showed clear reductions of caries for all adult age groups from the beginning of the '70s to 1985/86 in the range of 2 to 6 teeth (NCHS, 1987; NCHS, 1981; NIH, 1979). Adults between the ages of 30 and 44 had the highest caries decline. In the latest national survey (Winn et al, 1996), further reductions in caries prevalence were found in young adults and seniors, but not in 30 – 44-year-olds.

In contrast to Scandinavia and the USA, where preventive measures were intensified on a nation-wide basis in the 1970s and 1980s, caries preventive programs were implemented in the 1990 s as part of the national heath system in Germany (which covers over 90% of the population) (Splieth and Meyer, 1996; Künzel, 1996; Downer, 1991; Ainamo, 1987; NIDR, 1981). Thus, the caries decline in children and adolescents started later and is still continuing (Pieper, 2000; Schiffner and Reich, 1999a). There is insufficient epidemiological data on oral health, especially in adults. The only nationally representative surveys were limited to a few age groups, which differed for consecutive surveys (8–9 yrs, 13–14 yrs or 12 yrs, 35–44 and/or 45–54 yrs, 65–74 yrs). The first East German survey was conducted 3 years after the West German (Micheelis and Reich, 1999; Micheelis and Bauch, 1996). The most continuously covered age group were 35 – 44-year-olds in West Germany, which showed a slight reduction of caries prevalence of about 1 DMFT between 1978 and 1997 (Schiffner and Reich, 1999b; Naujoks, 1985).

In order to improve the knowledge of general and oral health in Germany, the Study of Health in Pomerania (SHIP) was initiated by the University of Greifswald in 1995. This population-based health survey encompasses a broad spectrum of health and lifestyle factors, and will allow for multiple analyses in terms of co-morbidity and risk combinations for crucial health problems, in addition to the prevalence estimations of diseases determining morbidity among adults in Vorpommern (West Pomerania) in the northeast of Germany. In the future, the results of SHIP will be supplemented by cohort, case-control, and intervention studies. The pilot phase of a SHIP follow-up study started at the beginning of 2002, preparing the way for incidence estimations.

The overall design of SHIP as well as the design and objectives of the oral health section have been published in previous reports (John et al, 2001; Hensel et al, 2002), which can be consulted for further details.

This paper will focus on the results of caries prevalence in the adult population of Pomerania in comparison to national and international data.

MATERIALS AND METHODS

Study Design

A representative sample of 7,008 women and men aged 20 – 79 years was drawn from Pomerania, Northeast Germany in two stages: Firstly, 32 communities in the region (all 3 cities and 12 towns plus a random selection of 17 out of 97 of the small towns and villages with < 1500 inhabitants) were selected. Secondly, within the communities a simple random sample was drawn from residence registries, stratified by gender and age. After the exclusion of 741 neutral dropouts (126 had died and 615 had moved away), a response rate of 68.8% was achieved during the study from 1997 to 2001. For comparison with other studies, data are presented in this paper for the WHO age groups starting at age 25 (N = 4022).

Oral Health Examination

The participants were invited to one of the two examination centers (University Clinics Greifswald/Examination Center Stralsund). Carious defects, fillings, secondary caries, and missing teeth were registered by surface with the exception of wisdom teeth, and the data were entered on-line into an entry program. For diagnosis and the calculation of the DMFT and DMFS indices, WHO criteria (1997) were followed using a periodontal probe (PCP 11, Hu Friedy). In addition, the care index (Filled Surfaces/(Decayed Surface + Filled Surfaces)) was calculated. All examinations were conducted in the dental examination room with professional illumination and without the use of a saliva ejector or air jet.

As Gülzow and Maeglin (1964) had shown that epidemiological surveys with full- and half-mouth recording had resulted in identical DMFT values due to the symmetrical intra-oral distribution of caries, fillings and missing teeth between the right and left side in groups, the examination for decayed and filled surfaces was performed in a half-mouth de-

sign on the right or left side in alternate patients. Test evaluations in the pilot phases and while the study was ongoing showed no statistically relevant right-left differences, meaning the half-mouth method presents a realistic view of caries prevalence. For a comparison with other full-mouth studies, the DFS values were doubled.

Quality Assurance and Quality Control

In order to achieve a high quality of the data, the eight SHIP dentists and 3 dental assistants were trained by one specialized cariologist in a preparatory phase according to the examination manual.

Before the start and during the study, a certification of these dentists and dental assistants took place as double examinations of 10 and 5 test participants, respectively, one to two weeks apart. The specialized cariologist was considered the gold-standard examiner and excellent Cohen-Kappa intra-examiner reliability coefficients (Fleiss, 1981) of 0.9 – 1.0 were reached on a surface-by-surface basis due to the high and easily detectable number of restorations; the inter-examiner reliability was 0.93 – 0.96.

The quality of data entry was tested with tape recordings that showed an extremely low rate of mistakes (mean of 0.19%).

During the study, semi-annual interim analyses included evaluations of the data for implausible examiner differences in mean values and distributions for the examined parameters, the frequency of entering "data not collectible", undefined missing entries, and examiner differences of the mean examination time.

Comparison with other National Data

The mean numbers of decayed, missing and filled teeth (DMFT) and surfaces (DMFS) were calculated by WHO age groups (10 year strata) and gender for a comparison with data from other surveys. A systematic literature review (Medline: "caries and prevalence and representative and adults" past 1985) revealed that very few surveys on caries prevalence including fillings and missing teeth were available in all adult age groups on a preferably nationally representative basis.

The only surveys that fulfilled all criteria were the US-American NHANE-Surveys (Winn et al, 1996). Data from several countries were excluded, as they had examined only specific age groups, e.g. in Niger (Petersen and Kaka, 1999). A comparison with the representative German surveys that examined fewer age groups was important to assess the representativeness of the Pomeranian sample. The results of the studies in Jönköping/Sweden (Hugoson et al, 1995) were also included, since regular (every 10 yrs since 1973) oral examinations were conducted on a representative sample from a medium-sized town. Thus, the Pomerania data were compared with other German, Swedish and US data.

RESULTS

The mean numbers DMFT and DMFS are shown by WHO age groups (10-year strata) and gender (Table 1). Young adults in Pomerania already have high mean DMFT values that increase steadily with age. Women exhibited consistently higher mean DMFT and DMFS values of about 1 tooth and 1 – 7 surfaces for the different age groups than did men.

The mean values for decayed surfaces including secondary caries in the adult population in Pomerania were very low (full mouth: 0.95 DS $\pm$ 3.3), and the mean values decreased with age (full mouth: mean 1.4 DS $\pm$ 4.6 for 25 – 34 yrs to 0.2 for 75 + yrs). The mean number of carious defects was the only parameter where women showed minimally lower values than men. Due to the very low prevalence of carious defects (DS), the treatment needs of Pomeranian adults were generally very low, FS and DFS differed minimally, and the care index (FS/DFS) was between 90% and 95% with slightly better values for women.

Table 2 lists the DFS figures and missing teeth in more detail for all participants and dentate individuals only. For comparison with other studies, the mean and standard deviation are presented and – because of the non-normal distribution – the statistically more appropriate median and the interquartile range are added. Fillings comprised the largest proportion of the DMFT and DMFS indices in young adults, while missing teeth dominated in seniors, where the proportion of edentulous individuals increased sharply from 11.8% (55–64 yrs) to 33.8% (65–74 yrs) and 47.7% (75 + yrs). Females exhibit generally higher values than males.

The mean DMFS scores in Pomerania were slightly higher than the values for the only two available nationally representative age groups in Germa-

Table 1 Mean numbers and standard deviation of decayed, missing and filled teeth (DMFT) half mouth, surfaces (DMFS) half mouth and decayed surfaces (DS) half mouth by WHO age groups and gender in Pomerania, Germany, 1997 – 2001

Age group (n)	DMFT ± Standard Dev.		DMFS ± Standard Dev.		DS ± Standard Dev.	
	female	male	female	male	female	male
25 – 34 y (699)	8.1 ± 2.7	7.1 ± 2.9	24.2 ± 12.9	20.7 ± 12.3	0.5 ± 1.6	1.1 ± 2.9
35 – 44 y (755)	9.5 ± 2.6	8.2 ± 2.9	34.0 ± 14.1	27.4 ± 14.0	0.6 ± 1.9	0.6 ± 1.4
45 – 54 y (744)	10.3 ± 2.5	8.7 ± 3.2	38.9 ± 14.7	31.9 ± 16.4	0.4 ± 1.7	0.5 ± 1.7
55 – 64 y (842)	10.9 ± 2.7	10.1 ± 3.3	44.8 ± 15.5	40.4 ± 17.4	0.3 ± 0.9	0.6 ± 2.0
65 – 74 y (682)	12.3 ± 2.3	11.9 ± 2.7	53.0 ± 13.8	52.1 ± 14.8	0.2 ± 0.8	0.3 ± 1.1
75 y + (300)	13.1 ± 1.5	12.6 ± 2.2	58.8 ± 8.4	55.9 ± 12.2	0.1 ± 0.3	0.2 ± 0.6

ny (Table 3). In comparison, the DMFS scores in US-American adults are generally lower than the Pomeranian and all-German data, especially up to the age of 44 years. The pattern of higher values for females is consistent in both countries.

Fig 1 illustrates the very high mean numbers of missing teeth (MT) in Pomeranian adults (2.7 – 23.3 MT) compared to the USA (2.0 – 11.9 MT) and especially Sweden (0.7 – 12.3 MT). In Pomeranian seniors, the extremely high rate of missing teeth coincides with comparatively low numbers of decayed or filled teeth (DFS). In contrast to this, young adults (25–34 years) in Pomerania show higher mean values for carious/filled surfaces (32.4 DFS) and missing teeth (2.7 MT) than their counterparts in the USA or Sweden, even at a 5-yrear higher mean age (USA: 16.5 DFS, 2.0 MT, Sweden: 23.2 DFS, 0.7 MT).

DISCUSSION

In the international comparison, the DMFT/S values in the adult population in Pomerania are high, but they differ only slightly from the recent representative German surveys that are available for two adult age groups (Schiffner and Reich, 1999b, c). East German adults – similar to the Pomeranian population – had higher rates of missing teeth, but fewer fillings than their West German counterparts, resulting in similar mean DMFT/S scores, equally low treatment needs, and high care indices (Schiffner and Reich, 1999b, c; Micheelis and Bauch, 1993, 1991).

A marked caries decline in the adult population such as that found in Sweden and the USA is not found in Germany (Hugoson et al, 2000; Schiffner and Reich, 1999a; Hugoson et al, 1995; NIH, 1987; NCHS, 1981; NCHS, 1979). The true difference between the German and Swedish data should be even slightly higher as radiographic diagnostics were additionally used in Sweden.

The reasons for these high values of filled and missing, but low number of carious teeth lie mainly in the German oral health care system. In contrast to the widespread and early use of water fluoridation in the USA, no collective fluoride use other than fluoridated toothpaste was introduced in Germany (Splieth et al, 1996; Künzel, 1996; CDC, 1985). Fluoridated table salt has only recently achieved significant market shares (van Steenkiste, 1995). In addition, until German reunification in 1990, fluoridated toothpaste was hardly available or effective in Pomerania and the whole of former East Germany (Treide, 1984).

Preventive measures up to the age of 18 years became part of the health fund programs later than in other industrialized countries, which led to a delayed decline of caries in children and adolescents. Instead, fillings and endodontic treatment were free of charge for about 90% of the German population covered by the National Health System, which still does not include professional tooth cleaning or brushing instructions for adults free of

Table 2 Prevalence of coronal caries (DFS values, calculated for full mouth) and number of teeth in dentate (full mouth recording) and all persons as well as proportion of edentulous subjects by WHO age groups and gender in Pomerania, Germany, 1997 – 2001 (Mean ± Standard deviation, *Median* ± *inter quartile range*)

Age group (yrs)		N 4022	DF-S in all N = 4022	DF-S in dentate N = 3523	Missing teeth in all N = 4022	Missing teeth in dentate N = 3523	Percent and number of edentulous N = 499
25–34	Male	318	29.0 ± 17.2 26.0 ± 26.0	29.0 ± 17.2 26.0 ± 26.0	2.6 ± 3.0 2.0 ± 4.0	2.6 ± 3.0 2.0 ± 4.0	0.0% N = 0
	Female	381–1	35.3 ± 18.4 34.0 ± 28.0	35.3 ± 18.4 34.0 ± 28.0	2.8 ± 3.4 2.0 ± 4.0	2.8 ± 3.4 2.0 ± 4.0	0.0% N = 0
	All	699–1	32.4 ± 18.2 30.0 ± 26.0	32.4 ± 18.2 30.0 ± 26.0	2.7 ± 3.2 2.0 ± 4.0	2.7 ± 3.2 2.0 ± 4.0	0.0% N = 0
35–44	Male	364	29.1 ± 17.6 26.0 ± 26.0	29.3 ± 17.6 26.0 ± 26.0	5.4 ± 5.0 4.0 ± 5.0	5.3 ± 4.8 4.0 ± 5.0	0.5% N = 2
	Female	391–1	38.2 ± 17.6 38.0 ± 24.0	38.2 ± 17.6 38.0 ± 24.0	6.3 ± 5.8 5.0 ± 6.0	6.3 ± 5.8 5.0 ± 6.0	0.0% N = 0
	All	755–1	33.8 ± 18.2 34.0 ± 26.0	33.9 ± 18.1 34.0 ± 26.0	5.9 ± 5.4 4.0 ± 6.0	5.8 ± 5.3 4.0 ± 6.0	0.3% N = 2
45–54	Male	341–1	25.0 ± 17.7 22.0 ± 24.0	25.5 ± 17.5 22.0 ± 24.0	8.3 ± 7.3 6.0 ± 8.5	7.8 ± 6.8 6.0 ± 8.0	2.1% N = 7
	Female	403–1	36.3 ± 20.2 38.0 ± 28.5	38.1 ± 19.0 40.0 ± 26.0	8.7 ± 7.3 7.0 ± 8.0	7.7 ± 6.1 6.0 ± 7.0	4.7% N = 19
	All	744–2	31.1 ± 19.9 30.0 ± 30.5	32.3 ± 19.3 31.0 ± 30.0	8.5 ± 7.3 6.0 ± 8.0	7.8 ± 6.4 6.0 ± 7.0	3.5% N = 26
55–64	Male	414–1	22.1 ± 18.9 20.0 ± 30.0	24.9 ± 18.3 22.0 ± 28.0	12.7 ± 9.0 10.0 ± 16.0	10.8 ± 7.6 9.0 ± 12.8	11.1% N = 46
	Female	428–1	25.8 ± 20.7 24.0 ± 32.0	29.4 ± 19.5 28.0 ± 32.0	13.6 ± 8.9 11.0 ± 15.0	11.5 ± 7.5 10.0 ± 13.0	12.4% N = 53
	All	842–2	24.0 ± 19.9 22.0 ± 32.0	27.2 ± 19.0 26.0 ± 30.0	13.2 ± 8.9 11.0 ± 16.0	11.2 ± 7.6 10.0 ± 12.0	11.8% N = 99
65–74	Male	382–1	11.9 ± 15.4 6.0 ± 20.0	17.9 ± 15.8 14.0 ± 22.0	20.0 ± 8.4 22.0 ± 14.0	16.0 ± 7.5 17.0 ± 12.0	33.5% N = 128
	Female	300–1	14.0 ± 17.2 8.0 ± 24.0	21.2 ± 17.2 18.0 ± 24.0	19.9 ± 8.4 22.0 ± 15.0	15.8 ± 7.5 17.0 ± 13.0	33.7% N = 101
	All	682–2	12.8 ± 16.2 6.0 ± 20.0	19.3 ± 16.5 16.0 ± 22.0	20.0 ± 8.4 22.0 ± 15.0	15.9 ± 7.5 17.0 ± 12.0	33.6% N = 229
75+	Male	163	7.6 ± 12.6 0.0 ± 12.0	14.1 ± 14.2 10.0 ± 22.0	22.9 ± 7.1 27.0 ± 9.0	18.4 ± 7.1 19.0 ± 12.0	46.6% N = 76
	Female	137	7.9 ± 13.9 0.0 ± 9.0	15.4 ± 16.2 8.0 ± 22.0	23.7 ± 6.1 27.0 ± 6.0	19.7 ± 6.2 22.0 ± 10.2	48.9% N = 67
	All	300	7.7 ± 13.2 0.0 ± 10.0	14.7 ± 15.1 10.0 ± 21.0	23.3 ± 6.6 27.0 ± 8.0	19.0 ± 6.7 21.0 ± 11.5	47.7% N = 143

Table 3 Mean numbers of decayed, missing and filled tooth surfaces (DMFS) by WHO age groups and gender in Pomerania, Germany (1997 – 2001), Germany as a whole (Schiffner and Reich 1999b, c), and the USA (Winn et al, 1996)

Age group	Pomerania (1997–2001)		Germany (1999)		USA (1988–91)	
	female	male	female	male	female	male
25 – 34 y	48.4	41.4			26.6	22.6
35 – 44 y	68.0	54.8	57.6	51.9	45.2	40.6
45 – 54 y	77.8	63.8			65.7	64.3
55 – 64 y	89.6	80.8			84.5	77.8
65 – 74 y	106.0	104.2	107.2	96.7	89.4	87.8
75 y +	117.6	111.8			100.6	102.4

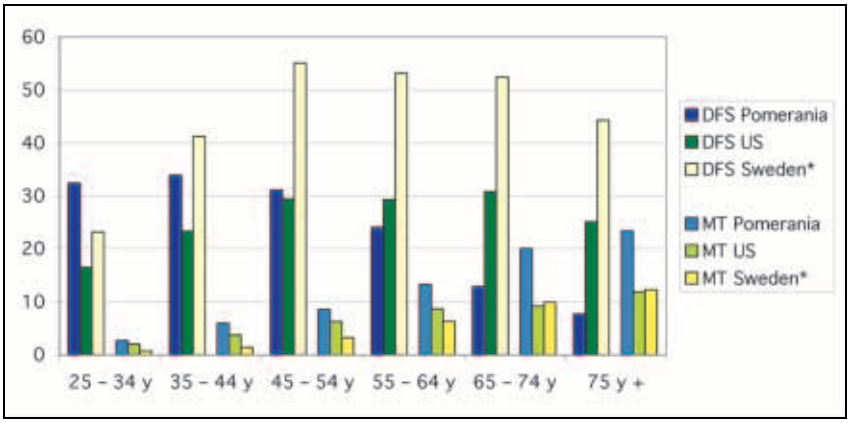

Fig 1 Mean numbers of decayed and filled tooth surfaces (DFS) and missing teeth (MT) by WHO age groups in all persons in Pomerania, Germany (SHIP, 1997-2001), the USA (NHANES, Winn et al, 1996), and Jönköping/Sweden (Hugoson et al, 1995, *age groups + 5 yrs).

charge. Therefore, the care index is very high and the motivation to avoid restorations is very low. In contrast, adults in Sweden and the USA must pay for restorations to a greater extent.

The lack of proper instruments in East Germany before unification often made endodontic treatment impossible and explains the higher numbers of missing teeth as compared to West Germany.

In summary, the high numbers of fillings and missing teeth and the high care index in the Pomeranian adult population reflect both the structure of the German national health coverage system, and the need for intensified preventive measures for adults.

ACKNOWLEDGEMENT

The analysis of these data is part of the DFG-Grant No. Ko 799/5-1.

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