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Change in FS-T index in adults in the German national oral health surveys between 1989 and 2005

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Abstract – *Objectives:* To assess changes in the number of functioning teeth (filled and sound teeth, FS-T index) from 1989/1992 to 2005 in West and East Germany and to evaluate survey- and region-specific associations between sociodemographic and behavioral risk factors and the FS-T index. *Methods:* Within the German Oral Health Studies, random samples from 35–44-year-olds were drawn in 1989, 1992, 1997 and 2005. The FS-T index and a questionnaire with socioeconomic and behavioral items were assessed. Negative binomial regression models were evaluated, including all sociodemographic and behavioral factors simultaneously as independent variables. *Results:* For West Germany, median FS-T index increased by 3 teeth between 1989 and 2005 ($P_{trend} < 0.001$). In East Germans, FS-T index was similar in 1992 and 1997 (median, 24), but increased by one tooth until 2005 ($P_{trend} < 0.001$). For West and East Germany, middle and high school education were significantly associated with higher FS-T indices in all surveys, although effects were most pronounced in 2005. Being married, reporting regular dental visits and good oral hygiene were significantly related to a higher number of functioning teeth in at least one survey year. *Conclusions:* Dental health assessed as the number of functioning teeth improved between 1989/92 and 2005 in both German parts and across all educational levels. However, considering the educational level, dental health was less equally distributed in 2005 compared with previous surveys.

Key words: adults; caries; FS-T index; German national oral health survey; risk factors

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The German reunification in 1990 provided the opportunity to study effects of different political and social systems and to follow the process of equalization after the reunification. The Institute of German Dentists (IDZ) has conducted four cross-sectional surveys of the oral health in the German resident population, covering the old and the new Federal States before and after the reunification.

Over the past decades, many studies have found that oral diseases are linked to various sociodemographic and behavioral factors (1–5). Holst et al. (4) described that the temporal changes in caries experience between 1983 and 2006 were related to educational level; disparities were only significant in 1983, but diminished in later surveys among 35–44-year-old adults in Norway. For Germany, the changing association between risk factors and caries status across consecutive surveys was not yet evaluated.

In Europe, several studies evaluated changes in caries status in adults over two or more surveys during the last 30 years (6–10). Most studies reported a caries decline (6–12). For Germany, information on caries prevalence in adults is rare

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(13–15), and information on period effects is restricted to surveys from 1997 and 2005 (13). Thus, little is known about change in dental health of adults in Germany, covering the time before and after the reunification.

When trying to separate age effects from period and cohort effects, three types of observable differences occur: longitudinal, cross-sectional and time-lag (16). Time-lag differences are differences between individuals of the same age in different years of survey; they are composed of period and cohort effects. Period effects mainly comprise changing physical and social environments within the cohort, whereas cohort effects comprehend historical differences in social and physical environments across cohorts.

The FS-T index, the number of filled and sound teeth, measures dental health and function of teeth (5, 17, 18). Further, FS-T index presented an increased model performance and might be more effective than the DMFT at revealing sociodemographic and behavioral factors associated with adult caries experience (5, 17, 18). Thus, the aim of this study was (i) to evaluate changes in FS-T index in 35–44-year-olds in repeated cross-sectional surveys conducted in 1989, 1992, 1997 and 2005, separating for region, and (ii) to determine the survey- and region-dependent association between sociodemographic and behavioral risk factors and FS-T index.

Materials and methods

Study design

The four German Oral Health Surveys ('Deutsche Mundgesundheitsstudien', DMS) were planned by the IDZ as representative cross-sectional studies of oral health in the German resident population. Data collection took place in 1989 [DMS I, only old Federal States (19)], 1992 [DMS II, only new Federal States (20)], 1997 [DMS III (21)] and 2005 [DMS IV (13)]. The design, sampling and nonresponse analyses for the four surveys have been described in detail elsewhere (13, 20, 22). First, cluster samples stratified by Federal State and by community category were selected, totaling to 80, 40, 90 and 90 municipalities (sample points), respectively. Second, random samples were drawn from registration offices from each of these municipalities.

The adult cohort with subjects aged 35–44 years was the only one represented in all four German Oral Health Studies. Birth cohorts included subjects born in 1945–1954, 1948–1957, 1953–1962 and 1961–1970. Participation was 56%, 72%, 56% and 52%, respectively (Table 1).

Dental examination

A dental examination and a questionnaire were used to collect data. Caries status was assessed by specially trained and calibrated dentists during oral examination as recommended by WHO (23). Examinations were performed by 80 dentists in private practices in DMS I, two mobile dental teams (calibrated dentist, interviewer and contact person) in DMS II and three mobile teams in DMS III and DMS IV.

The number of decayed and missing teeth (DM-T) was determined. Wisdom teeth were excluded. The FS-T index was calculated as 28-DM-T.

For all surveys, study dentists were intensively trained by experts before the start of the study. At the beginning, during and at the end of the survey, 80, 80, 104 and 123 subjects were examined by the study dentist and an expert to receive inter-rater correlations, respectively. Regarding the DMFT index, correlations between dentists and experts were high equaling 0.98, 0.98, 0.99 and 0.85 in DMS studies, respectively.

Socioeconomic and behavioral factors

Information on sociodemographic and behavioral factors was retrieved from the questionnaire. As

Table 1. Information on sampling design for adults in DMS I–IV

Survey name	Birth cohort	Survey year	Age (year)	Sampling size	Number of invited subjects	Participants (%)	Participants aged 35–44 years
DMS I	1945–1954	1989	35–54[a]	1700	1544	858 (56)	500
DMS II	1948–1957	1992	35–54[a]	1039	1014	731 (72)	364
DMS III	1953–1962	1997	35–44	1260	1179	655 (56)	655
DMS IV	1961–1970	2005	35–44	1980	1774	925 (52)	925

[a]Information was only available for complete cohort aged 35–54 years. For analyses, *only* subjects aged 35–44 years were considered.

the questionnaire partly differed across the four studies, we included only variables that were similarly collected in all surveys. For example, smoking was only assessed in DMS III and DMS IV and was thus omitted from analyses. School education was categorized into three categories (<10, 10 and >10 years). Marital status was categorized as married, single and widowed/divorced based on questions ('Which marital status do you have?'). Frequency of eating between-meal snacks ('How often do you eat snacks between meals?') was categorized into none, once or twice a day and at least thrice a day.

To assess oral healthcare status and use of oral health services, duration of tooth brushing (<2 or $\geq$2 min), tooth brushing frequency ('How often do you usually brush your teeth?', $\leq$1, 2 or $\geq$3 daily) and time since last dental visit (within the last 12 months, within the last 2 years or more seldom) were retrieved from the questionnaire.

A total 2444 subjects participated in the different cross-sectional DMS studies (Table 1). Forty-nine subjects were excluded because of missing data on caries status. Further, 98 subjects were excluded because of missing covariate data, leaving 437, 351, 618 and 891 subjects from DMS I, DMS II, DMS III and DMS IV, respectively, for analyses.

Statistical analyses

Data were presented as percentages. Distributions in variables according to survey year were analyzed using chi-square tests. Median FS-T index with interquartile range was presented. To evaluate changes in FS-T index across survey years within strata of sociodemographic and behavioral factors, *P* values for linear trends were determined using negative binomial models. Because FS-T index was negatively skewed, the difference between 28 and FS-T index, equaling the number of decayed and missing teeth (DM-T), was evaluated as the dependent variable.

To determine the survey- and region-dependent association between sociodemographic and behavioral risk factors and FS-T index, negative binomial regression models were evaluated for each combination of survey year and region. All sociodemographic and behavioral factors were simultaneously included as independent variables. For each model, variables were checked for collinearity using partial correlations. Incidence rate ratios (IRR) with 95% confidence intervals (CI) were reported. Ignoring the distribution of FS-T index, R^2 values from linear regression models were evaluated.

The significance level was set at 5% for all analyses. Statistical analyses were performed using STATA/SE 12.0 (24).

Results

Study population

Characteristics of studied populations according to sociodemographic and behavioral factors are given in Table 2. Distribution of school education, marital status, and reported duration of tooth brushing differed consistently across survey years both in West and East Germany ($P < 0.05$).

Across surveys, the FS-T index increased in both German parts (Table 3), although more pronounced in West Germany compared with East Germany. Single caries components showed varying patterns across surveys in both regions.

Distribution of FS-T index according to region and survey year

In West Germany, median FS-T index increased by 3 teeth between 1989 and 2005 ($P_{trend} < 0.001$, Table 4). For East Germans, FS-T index was similar in 1992 and 1997, but increased by one tooth between 1997 and 2005 ($P_{trend} < 0.001$). FS-T index increased within most factor strata between the first and the last survey in both regions, although more pronounced in West Germany.

Multivariate analyses

For West Germany (Table 5), middle and high school education were consistently associated with lower DM-T (higher FS-T) compared with low school education in all surveys, although effects were most pronounced in 2005. Other variables significantly contributing to higher DM-T (lower FS-T) in at least one survey year comprised age, single and divorced/widowed status and having visited the dentist within the last 2 years or more seldom. Ignoring the distribution of FS-T index, R^2 values from linear regression models were 10.8% (DMS I), 10.6% (DMS III) and 11.3% (DMS IV).

For East Germany (Table 6), high school education was consistently associated with lower DM-T (higher FS-T) compared with low school education in all surveys; again, effects were most pronounced in 2005. Age and having visited the dentist within the last 2 years or more seldom were related to

Table 2. Distribution of sociodemographic and behavioral variables according to region and survey year

Variable	West Germany				East Germany			
	1989 (*N* = 437)	1997 (*N* = 422)	2005 (*N* = 589)	*P**	1992 (*N* = 351)	1997 (*N* = 196)	2005 (*N* = 302)	*P**
Gender, %								
Male	52.4	53.1	55.5	0.57	49.6	53.6	57.0	0.17
Female	47.6	46.9	44.5		50.4	46.4	43.0	
Age (years), %								
35–39	56.1	49.5	49.8	0.08	63.8	45.9	47.0	<0.001
40–44	43.9	50.5	50.2		36.2	54.1	53.0	
School education, %								
<10 years	56.5	35.8	28.5	<0.001	21.9	16.3	12.6	0.02
10 years	22.0	34.1	35.5		51.9	55.6	61.6	
>10 years	21.5	30.1	36.0		26.2	28.1	25.8	
Marital status, %								
Married	81.0	77.0	71.3	0.001	85.5	76.0	68.5	<0.001
Single	12.1	13.7	20.5		9.1	9.7	22.5	
Divorced/widowed	6.9	9.3	8.2		5.4	14.3	8.9	
Frequency of eating between-meal snacks, %								
None	27.2	5.9	6.3	<0.001	9.1	5.6	6.0	0.24
Once or twice a day	60.2	51.0	51.4		65.8	63.3	63.9	
At least thrice a day	12.6	43.1	42.3		25.1	31.1	30.1	
Time since last dental visit, %								
Within the last 12 month	82.2	86.3	89.6	0.002	86.0	88.3	91.7	0.07
Within the last 2 years or more seldom	17.8	13.7	10.4		14.0	11.7	8.3	
Duration of tooth brushing, %								
<2 min	57.2	56.4	36.2	<0.001	72.9	64.3	45.7	<0.001
≥2 min	42.8	43.6	63.8		27.1	35.7	54.3	
Tooth brushing frequency, %								
<2 times/day	24.3	18.5	15.3	0.002	18.8	19.9	14.2	0.27
2 times/day	61.5	69.9	72.7		75.5	76.0	78.5	
>2 times/day	14.2	11.6	12.0		5.7	4.1	7.3	

*Chi-square test.

higher DM-T (lower FS-T) in at least one survey year. Subjects with middle school education, subjects brushing their teeth for ≥2 min or 2 times/day had significantly lower DM-T values (higher FS-T) compared with respective reference groups in at least one survey year. R^2 values from linear regression models were 8.7% (DMS II), 18.2% (DMS III) and 18.9% (DMS IV).

Discussion

In this study, marked changes in the FS-T index in 35–44-aged subjects were observed in West and East Germany between 1989/92 and 2005, covering the time before and after the reunification. In West Germany, the increase in FS-T index was more pronounced compared with East Germany, where the FS-T index increased only after 1997. Multivariate modeling revealed that school education was significantly associated with FS-T index in both regions and all survey years, although effects were consistently most pronounced in 2005.

Because there is considerable criticism on the DMFT index (5, 25, 26), we assessed the FS-T index. In previous studies, the FS-T index was more effective than the DMFT index at revealing sociodemographic and behavioral factors associated with adult caries experience (5, 25, 26). Further, explanatory variables explained a higher proportion of variation in FS-T index than DMFT index in most of these studies (5, 25, 26). However, the FS-T index has also some shortcomings. It assumes, like the DMFT and the DMFS, that 'missing and filled teeth were once carious', and it does not date caries attacks on teeth (5). Thus, functionality might not absolutely be related to previous caries experience.

In other European studies, an increase in the FS-T index in 35–44-year-olds was consistently found, confirming results from our study. In the UK, FS-T index increased from 21.1 in 1978 to 23.2 in 1988 and 23.8 in 1998 in 35–44-year-olds (27). Over

Table 3. Median (interquartile range) of FS-T index and single components according to region and survey year

	West Germany 1989 (N = 437)	1997 (N = 422)	2005 (N = 589)	East Germany 1992 (N = 351)	1997 (N = 196)	2005 (N = 302)
FS-T	23 (20–26)	25 (22–27)	26 (24–28)	24 (20–26)	24 (20–26)	25 (23–27)
ST	11 (7–14)	11 (8–15)	13 (9–17)	14 (11–18)	11 (7–16)	12 (9–16)
FT	12 (8–15)	13 (9–15)	12 (9–15)	8 (5–11)	11 (8–15)	12 (9–15)
DT	1 (0–3)	0 (0–0)	0 (0–0)	0 (0–1)	0 (0–1)	0 (0–1)
MT	2 (1–5)	3 (1–5)	1 (0–4)	3 (1–6)	4 (1–7)	2 (1–4)

ST, sound teeth; FT, filled teeth; DT, decayed teeth; MT, missing teeth; FS-T = FT + ST.

the last decades, the FS-T index also increased in Norway (8), Slovakia (10), and Switzerland (11).

Period and cohort effects related to improved FS-T indices

Several reasons were discussed to explain the caries decline in industrialized countries during the last 30 years. Fluoridation measures and socioeconomic factors mainly contributed to caries decline (28, 29). To explain changes in FS-T index in this study, a combination of period and cohort effects may be considered (16). In this setting, main period effects comprehend political and social changes introduced by the reunification in 1990 and the introduction of fluoridated toothpastes. Relevant cohort effects comprise historical differences in social or physical environments during critical earlier years.

The FS-T index reflects caries experience over lifetime, birth-year and growth period of study participants. After the Second World War, poor social conditions, reduced public utility infrastructure, poor health care and an economy of scarcity might have aggravated oral and general health care, affecting especially the cohorts examined in 1989 and 1992, who were born in 1945–1954 and 1948–1957.

The increase in FS-T index was more pronounced in West (Δ = 3 teeth) compared with East Germany (Δ = 1 tooth), while starting levels in 1992 (DMS II) were higher in East Germany. After the reunification in 1990, many changes in socioeconomic and political conditions occurred in East Germany. These included growing unemployment, transformation in family life, women's role and changes in the healthcare system. Massive changes in the oral health system might have led to modified treatment approaches and a shift toward restorative treatments, reflected in the increased number of filled teeth in East Germany (Table 3).

In parallel, fluoride exposure increased after 1970. In West Germany, fluoridated toothpastes were introduced in the early 1970s and reached about 40% (90%) of market penetration in the 1970s (1980s) (14, 30). In East Germany, preventive programs, fluoridated toothpastes and fluoride tablets were introduced in the early 1970s. Although 40% of adolescents reported the use of fluoridated toothpastes, the market share of fluoridated toothpastes was constantly about 10% in East Germany (30). After the reunification, fluoridated toothpastes covered more than 90% also in East Germany. Interestingly, regular tooth brushing was significantly related to a higher number of functioning teeth only in 1992 and 1997 (East Germany). Subjects with good oral hygiene might have been able to compensate insufficient supply of fluoridated toothpastes. Fluoridated salt was introduced in 1991 (31); until 2004, the market share increased to 63% (32). Assuming that fluoridation may be the more important factor affecting dental caries prevalence (2, 33), the late introduction of fluoridated toothpastes in the German Democratic Republic (GDR) might have contributed to the delayed and reduced increase in the FS-T index.

Varying relation of risk factors to FS-T index

Several studies reported on associations between socioeconomic and behavioral factors with dental health (2, 3, 5, 34–36). However, differences in association strengths of dental risk factors with the number of functioning teeth in repeated cross-sectional analyses were not quantified so far.

In this study, middle and high school education, as a proxy for socioeconomic status, were consistently associated with a higher number of functioning teeth, with differences being most pronounced in 2005. For West (East) Germany, predicted differences in DM-T between lower and upper levels of school education increased from 0.46 (0.25) in 1989 (1992) to 0.55 (0.65) teeth in 2005. School education reflects the knowledge about the importance of oral prevention, how to practice it correctly, and the ability to search appropriate solutions for problems (1). Further, sugar consumption is strongly related to the socioeconomic status (37). Obviously, highly

Table 4. Median FS-T index (interquartile range) according to sociodemographic and behavioral factors, by region and survey year

Variable	West Germany				East Germany			
	1989 (N = 437)	1997 (N = 422)	2005 (N = 589)	P_{trend}*	1992 (N = 351)	1997 (N = 196)	2005 (N = 302)	P_{trend}*
Overall	23 (20–26)	25 (22–27)	26 (24–28)	<0.001	24 (20–26)	24 (20–26)	25 (23–27)	<0.001
Gender								
Male	24 (20–26)	25 (22–27)	26 (24–28)	<0.001	24 (20–26)	25 (20–27)	25 (23–27)	0.002
Female	23 (20–26)	25 (22–27)	26 (24–28)	<0.001	24 (20–26)	23 (20–26)	26 (23–27)	<0.001
Age (years)								
	24 (20–26)	25 (23–27)	26 (24–28)	<0.001	24 (21–26)	24 (21–26)	26 (24–27)	<0.001
35–39								
	23 (20–26)	25 (22–27)	26 (23–28)	<0.001	24 (20–25)	23 (20–26)	25 (22–27)	0.003
40–44								
School education								
<10 years	22 (18–25)	24 (20–26)	25 (23–27)	<0.001	22 (19–24)	20 (14–25)	24 (20–26)	0.49
10 years	24 (21–27)	26 (23–27)	26 (23–28)	0.001	24 (21–26)	24 (21–26)	25 (23–27)	0.01
>10 years	25 (23–27)	26 (24–27)	27 (25–28)	<0.001	24 (21–27)	24 (22–27)	27 (25–28)	<0.001
Marital status								
Married	24 (20–26)	25 (23–27)	26 (24–28)	<0.001	24 (21–26)	24 (20–26)	25 (23–27)	<0.001
Single	23 (19–26)	25 (22–27)	27 (25–28)	<0.001	23 (20–26)	24 (20–26)	25 (23–27)	0.04
Divorced/widowed	22 (17–24)	24 (18–26)	25 (23–27)	0.052	22 (18–26)	24 (19–27)	26 (22–27)	0.11
Frequency of eating between-meal snacks								
None	23 (20–26)	26 (23–28)	26 (24–28)	<0.001	24 (20–27)	25 (22–28)	26 (25–27)	0.11
Once or twice a day	24 (20–26)	25 (23–27)	26 (24–28)	<0.001	24 (21–26)	24 (21–27)	26 (23–27)	<0.001
At least thrice a day	22 (19–25)	24 (22–27)	26 (24–27)	<0.001	23 (21–25)	24 (20–26)	25 (22–27)	0.06
Time since last dental visit								
Within the last 12 month	24 (20–26)	25 (23–27)	26 (24–28)	<0.001	24 (21–26)	24 (20–26)	25 (23–27)	<0.001
Within the last 2 years or more seldom	22 (17–26)	24 (19–26)	26 (23–27)	0.02	22 (19–25)	24 (14–27)	24 (20–26)	0.65
Duration of toothbrushing								
<2 min	23 (20–26)	25 (22–27)	26 (23–28)	<0.001	24 (20–25)	24 (20–26)	25 (22–27)	0.16
≥2 min	24 (20–26)	25 (23–27)	26 (24–28)	<0.001	24 (20–27)	24 (21–26)	26 (24–27)	<0.001
Tooth brushing frequency								
<2 times/day	24 (19–26)	25 (21–27)	26 (23–28)	<0.001	23 (19–25)	23 (13–25)	25 (23–27)	0.01
2 times/day	23 (20–26)	25 (23–27)	26 (24–28)	<0.001	25 (21–26)	24 (21–26)	25 (23–27)	<0.001
>2 times/day	23 (20–26)	24 (22–27)	26 (24–28)	<0.001	24 (21–26)	25 (17–27)	26 (23–27)	0.17

*Based on negative binomial regressions modeling decayed and missing teeth (DM-T = 28 − FS-T).

Table 5. Negative binomial regression analyses evaluating the association of decayed and missing teeth (DM-T = 28 − FS-T) with sociodemographic and behavioral factors in West Germany

	DMS I, 1989 (N = 437)		DMS III, 1997 (N = 422)		DMS IV, 2005 (N = 589)	
Variables	IRR (95% CI)	P	IRR (95% CI)	P	IRR (95% CI)	P
Gender (ref. female)						
Male	0.86 (0.72; 1.02)	0.08	0.94 (0.76; 1.16)	0.56	0.86 (0.69; 1.06)	0.15
Age (years)	1.02 (0.99; 1.05)	0.15	1.02 (0.99; 1.06)	0.18	1.05 (1.02; 1.09)	0.004
School education (ref. <10 years)						
10 years	0.74 (0.60; 0.91)	0.004	0.69 (0.54; 0.86)	0.001	0.78 (0.62; 0.99)	0.045
>10 years	0.54 (0.43; 0.67)	<0.001	0.56 (0.44; 0.71)	<0.001	0.45 (0.35; 0.58)	<0.001
Marital status (ref. married)						
Single	1.29 (1.00; 1.65)	0.046	1.01 (0.76; 1.34)	0.95	1.00 (0.77; 1.30)	0.98
Divorced/widowed	1.33 (0.98; 1.82)	0.07	1.39 (0.99; 1.93)	0.051	1.43 (1.02; 2.02)	0.04
Frequency of eating between-meal snacks (ref. none)						
Once or twice a day	1.05 (0.87; 1.27)	0.62	1.12 (0.73; 1.72)	0.61	1.12 (0.74; 1.71)	0.58
At least thrice a day	1.11 (0.85; 1.46)	0.44	1.25 (0.81; 1.93)	0.31	1.16 (0.76; 1.78)	0.49
Time since last dental visit (ref. Within the last 12 months)						
Within the last 2 years or more seldom	1.23 (0.99; 1.51)	0.051	1.49 (1.13; 1.97)	0.004	1.59 (1.16; 2.18)	0.004
Duration of tooth brushing (ref. <2 min)						
≥ 2 min	1.00 (0.85; 1.18)	0.96	0.84 (0.69; 1.02)	0.08	1.01 (0.82; 1.25)	0.92
Tooth brushing frequency (ref. <2 times/day)						
2 times/day	0.99 (0.81; 1.22)	0.96	0.95 (0.72; 1.24)	0.70	0.96 (0.73; 1.27)	0.79
>2 times/day	0.96 (0.72; 1.27)	0.76	1.23 (0.83; 1.80)	0.30	0.96 (0.65; 1.40)	0.81
R^2 from linear regressions	10.8%		10.6%		11.3%	

IRR, Incidence rate ratio with 95% confidence intervals (CI) and P values are given.
Gray shading indicates $p < 0.05$.

Table 6. Negative binomial regression analyses evaluating the association of decayed and missing teeth (DM-T = 28 − FS-T) with sociodemographic and behavioral factors in East Germany

	DMS II, 1992 (N = 351)		DMS III, 1997 (N = 196)		DMS IV, 2005 (N = 302)	
Variables	IRR (95% CI)	P	IRR (95% CI)	P	IRR (95% CI)	P
Gender (ref. female)						
Male	0.99 (0.82; 1.18)	0.88	0.80 (0.60; 1.07)	0.13	0.96 (0.75; 1.23)	0.74
Age (years)	1.04 (1.01; 1.07)	0.02	1.03 (0.99; 1.08)	0.16	1.06 (1.02; 1.11)	0.002
School education (ref. <10 years)						
10 years	0.80 (0.63; 1.01)	0.06	0.57 (0.40; 0.81)	0.002	0.75 (0.54; 1.06)	0.10
>10 years	0.75 (0.57; 0.97)	0.03	0.49 (0.32; 0.74)	0.001	0.35 (0.24; 0.539	<0.001
Marital status (ref. married)						
Single	1.14 (0.84; 1.55)	0.40	1.02 (0.64; 1.62)	0.93	1.07 (0.81; 1.42)	0.63
Divorced/widowed	1.39 (0.95; 2.06)	0.09	0.91 (0.62; 1.32)	0.62	0.91 (0.61; 1.35)	0.64
Frequency of eating between-meal snacks (ref. none)						
Once or twice a day	1.01 (0.74; 1.38)	0.94	1.60 (0.89; 2.89)	0.12	1.03 (0.62; 1.71)	0.92
At least thrice a day	1.03 (0.73; 1.45)	0.89	1.57 (0.85; 2.91)	0.15	1.30 (0.77; 2.21)	0.32
Time since last dental visit (ref. Within the last 12 months)						
Within the last 2 years or more seldom	1.22 (0.94; 1.58)	0.14	0.99 (0.66; 1.49)	0.97	1.59 (1.06; 2.39)	0.02
Duration of tooth brushing (ref. <2 min)						
≥ 2 min	0.95 (0.78; 1.17)	0.65	1.15 (0.86; 1.53)	0.35	0.69 (0.55; 0.88)	0.003
Tooth brushing frequency (ref. <2 times/day)						
2 times/day	0.75 (0.59; 0.96)	0.02	0.52 (0.37; 0.74)	<0.001	1.15 (0.82; 1.62)	0.43
>2 times/day	0.83 (0.54; 1.27)	0.39	0.78 (0.38; 1.64)	0.52	1.11 (0.66; 1.88)	0.69
R^2 from linear regressions	8.7%		18.2%		18.9%	

IRR, Incidence rate ratio with 95% confidence intervals (CI) and P values are given.
Gray shading indicates $p < 0.05$.

educated subjects profited more from oral health–enhancing programs than less educated subjects in later years.

Globalization and the rise of neoliberalism in the last two decades lead to the decline of the welfare state in many countries (38). This was well reflected in a broader social gradient and in a reduced oral health for subjects with low education in this study. Consistently, significant differences according to socioeconomic status were also found in Sweden (39), the UK (37) and Denmark (36, 40). In a Norwegian study, differences in dental status according to socioeconomic variables were less pronounced in 2006 compared with 1983 (4). Norway seems to be one of the few countries that could reduce social inequality in oral health.

Here, age, being married, reporting regular dental visits and good oral hygiene were significantly related to higher numbers of functioning teeth in some models. Results were consistent with other studies reporting protective effects of being married or cohabiting (36), regular dental visits (36, 40, 41) and good oral hygiene (5, 36).

For both regions, Pseudo-R^2 values increased across survey years, suggesting an improved model performance in later surveys. Ignoring the distribution of FS-T index, linear regression models provided R^2 values between 8.7% (DMS II, East Germany) and 18.9% (DMS IV, East Germany), indicating that only a low percentage of variation in the FS-T index was explained. However, these findings are in accordance with others (29, 42). Residual variation might be further explained by unmeasured risk factors, for example, smoking, mental status and social determinants. Regrettably, these variables were not collected consistently in DMS surveys and were thus not considered for analyses. As caries and related risk factors evolve with time, levels of hygiene and oral prevention in childhood and adolescence might have contributed to a better explanation of the dental status (5).

Study limitations comprise a putative information bias regarding questionnaires and a selection bias because of nonresponders. Over-reporting of socially accepted behaviors such as high tooth brushing frequency and duration and under-reporting of less-accepted behavior such as eating snacks between principal meals might have occurred (43). The higher response for East Germany in DMS II (72%) was also found in other studies (44, 45), combined with a higher attendance for conversion in nonresponders (46). The fact that this high response rate was achieved was certainly because subjects were not yet 'over-researched and tired of being interviewed' as a result of market research and other survey institutes (45). Nonresponse analyses included a short questionnaire that was sent to nonresponders. From the results, it can be concluded that nonresponse may not lead to serious bias, although responders tended to go to the dentist somewhat more frequently and the participation among women was higher than among men (47). However, as both factors counterbalance each other regarding the FS-T index (Tables 5 and 6), the higher response rate might not have affected the numbers of functioning teeth. Overall, changes in FS-T index between surveys because of measurement errors might be negligible.

In summary, analyses of repeated cross-sectional studies revealed that the FS-T index increased in German adults, although more pronounced in West compared with East Germany. In 2005, differences in the number of functioning teeth between subjects with low and high school education were most pronounced, reflecting a broader social gradient.

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Conflict of interest

There are no conflicts of interest associated with this work.

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