



## Dental and periodontal health in Finnish adults in 2000 and 2011

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### ABSTRACT

**Objective:** We assessed dental and periodontal health in adults aged  $\geq 30$  years living in southern and northern Finland as part of the Health 2000/2011 Surveys (BRIF8901).

**Material and methods:** Clinical findings in 2000 ( $n = 2967$ ) and 2011 ( $n = 1496$ ) included the presence of teeth and number of teeth with caries, fillings, fractures or periodontal pockets.

**Results:** Edentulousness decreased in all age groups. The prevalence of those with no caries increased from 67% to 69% in men and from 80% to 85% in women, and of those with no periodontal pocketing from 26% to 30% in men and from 39% to 42% in women. In 2011, the mean number of decayed teeth was 0.8 in men and 0.3 in women, and the corresponding mean numbers of teeth with deepened periodontal pockets 5.6 and 3.7. The gender difference had levelled concerning edentulousness, number of teeth and DMF teeth, but still existed in the occurrence of caries and periodontal pocketing.

**Conclusion:** The findings were in line with other population-based reports in the 2000s. However, periodontal health in Finland seems not to be as good as in many European countries and in the USA.

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### Introduction

Population-based data series are needed to monitor changes in health status of a population. However, nationwide representative studies on clinically determined dental and periodontal health in adult populations are scarce. The longest series come from the United Kingdom, with reports on adults' dental health every 10 years since 1968, the most recent carried out in 2009 [1]. Other nationwide cross-sectional data series are available from the USA from the 1960s to 2012 [2], Germany in 1989, 1992, 1997, 2005 and 2014 [3], Hungary in 1985, 1991, 2000 and 2003 [4], Denmark in 1982, 1994, 2000 and 2008 [5–8], Spain in 1984, 1993, 2000, 2005 and 2010 [9], South-Korea in 1998, 2001, 2005, 2007–9 and 2010–12 [10] and Finland in 1980 and 2000 [11,12]. In addition, national data on oral health in the 2000s are available from Austria in 2000 [13] and Kosovo in 2011 [14] and geographically restricted local data from Sweden [15–17], Norway [18] and France [19]. The repeated surveys [1–9,11,12] have revealed parallel trends, that is, an improvement of dental and periodontal health and a decrease in edentulousness. Detailed comparisons between the populations are, however, complicated because of differences in samples and age groups used for reporting, in the methods of clinical measurements, and in the definitions of indices especially describing dental and periodontal health.

The most reliable data for comparisons are probably for edentulousness which has shown a rapid decrease in many developed countries [4,20,21] and this has also been the case in Finland [12]. The same surveys report a steady increase over the decades in numbers of teeth in the dentate population and in percentages of those with at least 20 or 21 teeth. The occurrence of untreated dental caries has also decreased for example among the 35- to 44-year-olds in the United Kingdom from 51% in 1998 [22] to 30% in 2009 [23] and in Finland from 61% in 1980 [11] to 31% in 2000 [12]. In general, periodontal health has improved during the last two or three decades in many European countries and in the USA. The national surveys in the United Kingdom from 1998 to 2009 [23], in the USA from 1988–1994 to 1999–2004 [24] and in Spain from 2000 to 2010 [25] showed an increase of 10–15 percentage points (pp) in the prevalence of adults without periodontal pocketing i.e. having no teeth with deepened ( $\geq 4$  mm) periodontal pockets. The respective change in Finland from 1980 to 2000 was 13 pp [12] the prevalence, however, being still in a high (64%) level. A recent review on epidemiologic data from national cross-sectional surveys [26] showed large variation by country in the prevalence of those without periodontal pocketing. Among the 35- to 44-year-olds, this ranged from 84% in Austria and Spain [13,25] to 73–57% in Hungary, Denmark and the United Kingdom [5,23,27] to 27% in Germany [28].

According to data available, the main oral diseases, caries and periodontal diseases, are common non-communicable diseases. Also in Finland, oral diseases have earlier been quite prevalent, periodontal diseases having been the single most common type of the diseases at the beginning of the 2000s' [12]. Yet the resources to solve the problems are limited and therefore repeated surveys describing trends and producing up-to-date information on oral health are needed. This is to ensure equitable services for all in order to prevent diseases and to develop care. However, nationally representative surveys including clinical examinations are expensive and time-consuming to conduct. Regarding oral health they are especially valuable since most of the oral diseases cannot be evaluated by interviews or questionnaires. Information they yield is emphasized in situations where changes related to the organization of health care occur, for example, such as in Finland where a major health, social services and regional government reform is upcoming in beginning of the 2020s. Up-to-date information can be used to evaluate changes between years inside a country but also for international comparisons. Therefore, based on nationwide health examination surveys in Finland in 2000 and in 2011, we assessed here 11-year changes in dental and periodontal health in adults living in southern and northern parts of Finland.

## Material and methods

A national Health 2000 Survey was conducted by the National Institute for Health and Welfare (THL, previously the National Public Health Institute, KTL) in Finland [<http://www.terveys2000.fi/indexe.html>]. The stratified two-stage cluster sample was representative of the Finnish adult population aged 18 years and older, including institutionalized subjects [29]. From each of the five university hospital districts covering the whole country, 16 clusters (health centers) were selected. The 15 largest towns were all included and 65 other health centres were added according to the probability proportional to their size. The individuals in these 80 health centres were selected using systematic random sampling. The main sample included persons aged 30 years and older (8028) of which 6335 underwent clinical oral health examinations the participation rate being 79%.

The Health 2011 Survey was a follow-up study of the Health 2000 Survey. All study subjects of the Health 2000 Survey aged 18 years or older in 2000 and who were alive and living in Finland, excluding those denied, were invited. The sample of those aged 30 or over in 2011 consisted of 7964 adults, of whom 5806 (73%) participated in at least one part of the study and 4218 (53%) the health examination. Due to limited resources in the Health 2011 Survey, the clinical oral health examinations covered only two parts of Finland, that is, southern (Hospital Districts of Helsinki and Uusimaa) and northern (Hospital Districts of Kainuu, Keski-Pohjanmaa, Pohjois-Pohjanmaa, Lappi, Länsi-Pohja, Pohjois-Savo and Vaasa) Finland [30]. Participation rate to clinical oral health examination was 41%, 38% in the southern and 45% in the northern Finland. The Health 2011 Survey was conducted similarly as the Health 2000 Survey and the clinical

oral health examinations followed the same scheme as in the 2000 Survey [12]. The piloting took place in April and the two-week training of the examiners in July–August 2011. The clinical examinations including oral health went on from August to December. Both the Surveys were approved by the Ethics Committee for Epidemiology and Public Health of the Hospital District of Helsinki and Uusimaa, Finland (BRIF8901, 407/E3/2000/terveys2000 for the Health 2000 Survey, 45/13/03/00/11 for the Health 2011 Survey). All participants gave their written informed consent.

To ensure comparability, this study analysed the cross-sectional findings of the clinical oral health examinations among participants aged  $\geq 30$ -year old conducted in the southern (Hospital Districts of Helsinki and Uusimaa) and northern (Hospital Districts of Kainuu, Keski-Pohjanmaa, Pohjois-Pohjanmaa, Lappi, Länsi-Pohja, Pohjois-Savo and Vaasa) parts of Finland both in the Health 2000 and 2011 Surveys. The data thus covered  $n = 2967$  participants in 2000 and  $n = 1496$  in 2011. Participants' mean age and gender or education distributions were quite similar in those who attended clinical oral health examinations in the Health 2000 subpopulation (=southern and northern Finland) and in the whole Health 2000 Survey (Table 1). The same goes for the participants in oral health examinations (=southern and northern Finland) and health examinations (=whole country) in the Health 2011 Survey. In 2000, age was slightly but still statistically significantly higher in the whole Health 2000 Survey than in the subpopulation. In both years, distributions of educational levels were statistically significantly different between the whole country and the subpopulations. However, shapes of the distributions were similar, for example, participants with basic education represented highest proportions both in the whole survey and in the subpopulation in 2000 and those with higher education both in the whole survey and in the subpopulation in 2011, respectively.

In both surveys, a dentist-nurse team carried out the clinical oral health examinations using a fibre-optic headlamp, a dental treatment unit including a built-in compressor, a high-powered suction motor, and a portable patient chair. Saliva suction and fibre-optic light were at hand. The participants were first asked: 'Do you have any health condition for which your doctor or dentist has said you require antibiotic protection in connection with dental care?' If yes, periodontal measurements were excluded.

Tooth-based recordings included the status of all teeth (maximum 32) as well as the depth of periodontal pockets, excluding wisdom teeth. All surfaces were inspected and the dental status of each tooth was recorded as sound and untreated, fractured, filled, decayed (lesions reaching dentine, coronal and root caries), decayed radix a non-decayed radix. The depth of periodontal pockets was measured with a ball-ended WHO periodontal probe at four points of the tooth (distal angle, midpoint of buccal site, midpoint of lingual site and mesial angle) and recorded by tooth according to the deepest probing pocket depth (PPD) as no pocket, pocket of 4–5 mm or pocket of 6 mm and deeper.

The indicators describing dental health were the number of teeth, the number of decayed, missing, or filled (DMF) teeth, the number of sound and untreated teeth, the number

**Table 1.** Weighted<sup>a</sup> means and proportions of age, gender and level of education among the  $\geq 30$  years old participants in health and clinical oral health examinations in the Health 2000 and 2011 Surveys.

	The Health 2000 Survey: health examination including clinical oral health examination for the whole country		The Health 2011 Survey: health examination for the whole country, clinical oral health examination only in southern and northern Finland	
	Clinical oral health examination		Health examination Whole country $n = 4167$	Clinical oral health examination Southern and northern Finland <sup>b</sup> $n = 1496$
	Whole country $n = 6335$	Southern and northern Finland <sup>b</sup> $n = 2970$		
	Mean (SE <sup>c</sup> )			
Age (yrs)	52.1 (0.2) <sup>d</sup>	51.3 (0.3) <sup>d</sup>	54.0 (0.3) <sup>e</sup>	53.5 (0.5) <sup>e</sup>
Number of teeth	19.9 (0.2) <sup>f</sup>	20.2 (0.2) <sup>f</sup>	–	23.0 (0.3)
Women	52	53	53	52
		$p = .219^f$		$p = .590^f$
Level of education				
Basic	39	35	25	22
Middle	33	32	36	32
Higher	28	33	39	46
		$p < .001^g$		$p < .001^g$

<sup>a</sup>Sampling weights were in 2000 were based on age, sex, living area and mother language and in 2011 age, sex, education, physical activity, use of alcohol, use of vegetables, size of household and body mass index.

<sup>b</sup>Hospital Districts of Helsinki and Uusimaa in Southern Finland, and Hospital Districts of Kainuu, Keski-Pohjanmaa, Pohjois-Pohjanmaa, Lappi, Länsi-Pohja, Pohjois-Savo and Vaasa in Northern Finland.

<sup>c</sup>Standard Error.

<sup>d</sup>95% confidence intervals for difference between the means:  $-1.24$  and  $(-0.34)$ .

<sup>e</sup>95% confidence intervals for difference between the means:  $-1.34$  and  $0.34$ .

<sup>f</sup>95% confidence intervals for difference between the means:  $-0.14$  and  $0.71$ .

<sup>g</sup>Chi-square test.

of decayed teeth (DT), the number of filled teeth with no caries (FT) and the number of teeth with a fracture either in a tooth or filling (FrT). The presence and number of DT describe the caries situation and of DT+FrT, the need for restorative therapy. The number of teeth was categorized as none, 1–19 teeth, 20–24 teeth or 25–32 teeth.

The indicators of periodontal health were numbers of teeth with no deepened pockets (PPD  $< 4$  mm), with any deepened pockets (PPD  $\geq 4$  mm), and with deep pockets (PPD  $\geq 6$  mm). The severity of periodontal status was defined according to number of teeth with PPD  $\geq 4$  mm and categorized as 1–2 teeth (mild), 3–7 teeth (moderate) or 8 or more teeth affected (severe). These categories were chosen because they were similar to those used in reporting of periodontal data in the previous NHANES study [31,32] where the categories were at least 5, 10 and 30% of teeth having PPD  $\geq 4$  mm of the number of teeth.

Participants' age was determined in years and categorized in the analyses to 30- to 44-year-olds, 45- to 54-year-olds, 55- to 64-year-olds and 65-year-olds and over. In addition, we present selected findings for the two age groups defined by the WHO: 35- to 44-year-olds and 65- to 74-year-olds.

To obtain representative results for the target population, both the surveys used stratified cluster sampling and took into account the non-response rate by using weight coefficients. The data analyses were performed using SAS Callable SUDAAN software (Release 11.0) to take into account the two-stage cluster sampling design and weights. The sampling weights were in 2000 based on age, sex, living area and mother language and in 2011 age, sex, education, physical activity, use of alcohol, use of vegetables, size of household and body mass index [30]. Distributions of the continuous variables were checked and found not normally distributed based both on statistical tests (Shapiro–Wilks and Kolmogorov–Smirnov) and visual inspection.

Comparisons between the years 2000 and 2011 are based on descriptive statistics, such as distributions, medians, interquartile ranges (IQR), mean values and standard errors of the means (SE). Changes from 2000 to 2011 are also shown as percentage points (pp) calculated as differences between the prevalence figures. Chi-squared tests were used to test statistical significance between the years 2000 and 2011 and the categorized variables.

## Results

### Participants according to dental and periodontal findings

Edentulousness decreased across the 11 years and was 7% for men and 8% for women in 2011 (Table 2). Despite the overall decreasing trend, edentulousness remained quite frequent in the elderly (aged 65 years and older, Figure 1): 18% of men and 24% of women were edentulous in 2011 ( $p = .209$ ). For the 65- to 74-year-olds, the prevalences were 10% in men and 12% in women ( $p = .453$ ).

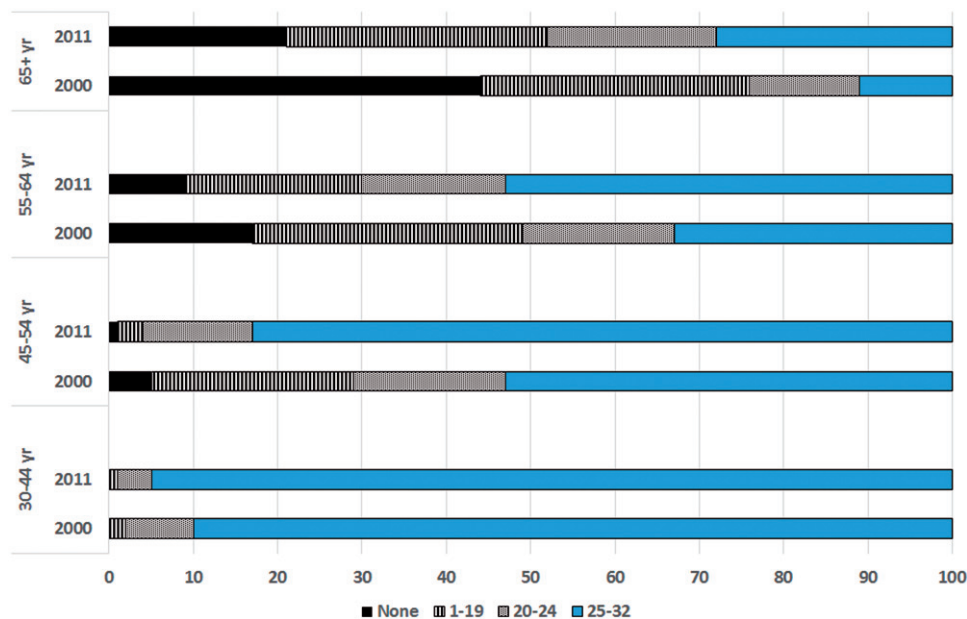
Number of sound teeth increased notably from 2000 to 2011. For those having at least 15 sound and untreated teeth, the increase was 11 pp in men and 13 pp in women, yielding a prevalence of 36% for men and 35% for women in 2011 (Table 2).

The occurrence of caries (DT  $> 0$ ) decreased and in 2011, the vast majority, 69% of men and 85% of women, had no decayed teeth (DT = 0). These figures were stable across the age groups. The proportion of participants having DT  $\geq 3$  was 8% for men and 3% for women in 2011 (Table 2). Considering the WHO age groups, 76% of the 35- to 44-year-olds had no decayed teeth (DT = 0) in 2000 and 75% in 2011; for the 65- to 74-year-olds, this figure increased by 20 pp, from 66% in 2000 up to 86% in 2011.

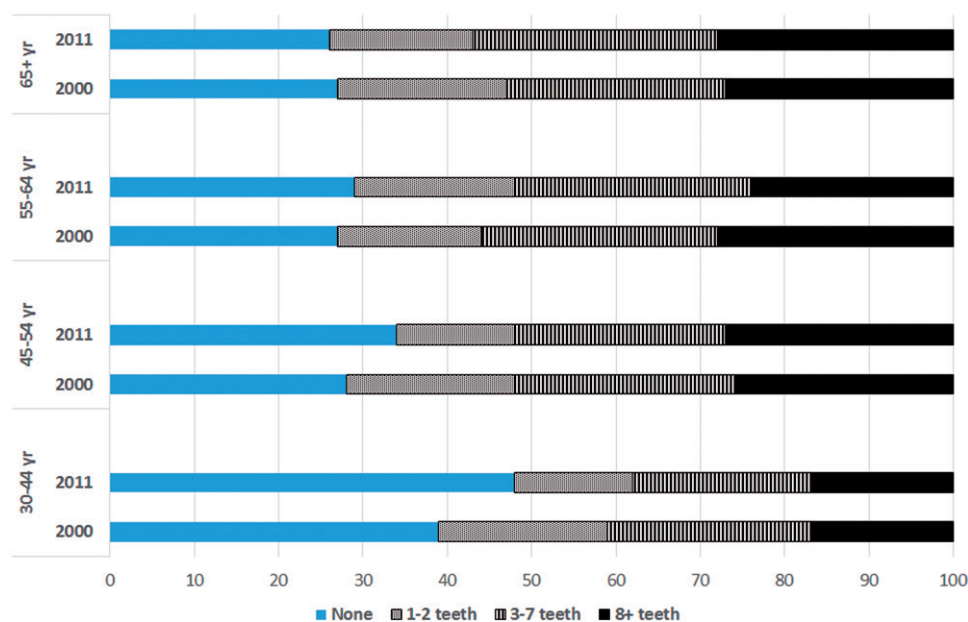
**Table 2.** Weighted<sup>a</sup> distributions (%) of participants aged 30+ years by categorized clinical findings and gender in 2000 and 2011. Statistical evaluation by Chi squared tests.

Clinical findings	Men		Women	
	2000	2011	2000	2011
	%			
No. of teeth	<i>n</i> = 1321	<i>n</i> = 667	<i>n</i> = 1646	<i>n</i> = 829
0	10	7	16	8
1-19	19	14	19	12
20-24	15	12	12	13
25-32	56	67	53	67
	<i>p</i> < .001		<i>p</i> < .001	
No. of sound teeth (no fillings, fractures or dental caries)	<i>n</i> = 1184	<i>n</i> = 623	<i>n</i> = 1358	<i>n</i> = 770
0	7	4	8	6
1-4	15	12	17	12
5-14	53	48	53	47
15+	25	36	22	35
	<i>p</i> < .001		<i>p</i> < .001	
No. of decayed teeth (dental caries)	<i>n</i> = 1181	<i>n</i> = 623	<i>n</i> = 1357	<i>n</i> = 770
0	67	69	80	85
1-2	22	23	15	12
3+	11	8	5	3
	<i>p</i> = .186		<i>p</i> = .064	
No. of decayed and/or fractured teeth (in need of restorative therapy)	<i>n</i> = 1181	<i>n</i> = 623	<i>n</i> = 1357	<i>n</i> = 770
0	59	56	72	75
1-2	27	31	21	19
3+	14	13	7	6
	<i>p</i> = .325		<i>p</i> = .552	
No. of teeth with deepened periodontal pockets (≥ 4 mm) (excluding wisdom teeth)	<i>n</i> = 1162	<i>n</i> = 609	<i>n</i> = 1327	<i>n</i> = 748
0	26	30	39	42
1-2	19	15	20	16
3-7	27	27	24	24
8+	28	28	17	18
	<i>p</i> = .125		<i>p</i> = .282	
No. of teeth with deepened periodontal pockets (≥ 6 mm) (excluding wisdom teeth)	<i>n</i> = 1162	<i>n</i> = 609	<i>n</i> = 1327	<i>n</i> = 748
0	75	79	84	86
1-2	14	12	10	8
3-7	8	7	4	5
8+	3	2	2	1
	<i>p</i> = 0.250		<i>p</i> = 0.020	

<sup>a</sup>Sampling weights were in 2000 were based on age, sex, living area and mother language and in 2011 age, sex, education, physical activity, use of alcohol, use of vegetables, size of household and body mass index.



**Figure 1.** Weighted distributions (%) of participants by categorized numbers of teeth and age groups 2000 and 2011 in southern and northern Finland.



**Figure 2.** Weighted distributions (%) of participants by categorized numbers of teeth with deepened periodontal pockets ( $\geq 4$ mm) and age groups in 2000 and 2011 in southern and northern Finland.

The need for restorative therapy (DT+FrT) showed practically no change, and in 2011, the majority of men (56%) and women (75%) had no such need (Table 2). By age group, the changes were minor, except for those aged 65 and older.

The percentage of those with no periodontal pocketing (PPD  $< 4$ mm) increased slightly from 2000 to 2011 and was 30% in men and 42% in women. On the other hand, 28% of men and 18% of women had 8 or more teeth with PPD  $\geq 4$ mm (Table 2). In the WHO age groups, the prevalence of periodontal pocketing (PPD  $\geq 4$ mm) decreased in 35- to 44-year-olds by 11 pp to 56% and in 65- to 74-year-olds by 10 pp to 71%.

Figure 2 shows the changes in the severity of disease from 2000 to 2011 by age groups. The proportion of those with no periodontal pocketing increased in all age groups; this was most clearly seen in younger patients. Despite the improvement in periodontal health, among those having 3–7 teeth or 8+ teeth with PPD  $\geq 4$ mm periodontal pocketing was seen also in the youngest age group (30–44-year-olds), in 41% of the subjects in 2000 and in 38% in 2011.

### Extent of dental and periodontal findings

Among the dentate subjects, the mean number of teeth increased to be about 25 in 2011, the change being 1.3 teeth for men and 1.7 teeth for women. Numbers of sound and untreated teeth increased and DMF teeth decreased, both by 2.2 teeth in men and by 2.5 teeth in women (Table 3). Among the 35- to 44-year-olds, the number of DMF teeth decreased by 5.4 in men and 6.3 in women and among the 65- to 74-year-olds, increased by 1.6 in men and 1.3 in women.

Mean numbers of DT were only slightly smaller in 2011 than in 2000: for men 0.8 and for women 0.3 (Table 3). Similarly, mean numbers of teeth in need of restorative therapy and filled teeth decreased slightly from 2000 to 2011. In

the WHO age groups, the decrease in DT was 0.2–0.5 for men and 0.0–0.3 for women.

From 2000 to 2011, mean numbers of teeth with no periodontal pocketing increased by 1.3–1.8 teeth up to 18.2 in men and 20.5 in women in 2011 (Table 3). Concurrently, there was no change in mean numbers of teeth with any periodontal pockets and minor decrease in teeth with deep pockets. In the younger WHO age group, numbers of teeth with no periodontal pocketing increased in women but not in men; for the 65- to 74-year-olds the increased both in men and women.

### Discussion

Dental and periodontal health improved moderately over the 11-year period as seen in the increase in numbers of teeth, numbers of sound teeth and numbers of teeth with no periodontal pocketing and in the decrease in numbers of DMFT and DT. However, prevalence of periodontal pocketing was still high and moderate or severe pocketing was seen also in the youngest age group. Among the young men, the number of teeth with deepened periodontal pockets slightly increased, posing a serious challenge for oral health care. In 2011, the gender difference had levelled off with regard to edentulousness and numbers of teeth and DMF teeth. Men still had both caries and deepened periodontal pockets more often than women. Differences between the age groups were obvious; the older the participants, the poorer oral health they had in terms of fewer teeth and higher number of teeth with deepened periodontal pockets.

Edentulousness decreased markedly and had practically disappeared in the younger age groups and was more than halved in the older ones. In 2011, 7% of all adults and 21% of those aged 65 year or over were edentulous. These prevalences are in the same level than in many other countries around 2010s [4,20,21,25,33]. Higher proportions based on

**Table 3.** Dental and periodontal findings in terms of weighted<sup>a</sup> medians, interquartile ranges (IQR), means and standard errors (SE) in 2000 and 2011 for all dentate participants aged 30+ years and separately for the two WHO index age groups, 35- to 44-year-olds and 65- to 74-year-olds.

Clinical findings	Men		Women	
	Median (IQR)/Mean (SE)		Median (IQR)/Mean (SE)	
	2000	2011	2000	2011
All dentate	<i>n</i> = 1185	<i>n</i> = 623	<i>n</i> = 1360	<i>n</i> = 770
No. of teeth	26.2 (7.2)/23.5 (0.2)	27.0 (4.8)/24.8 (0.4)	26.0 (7.5)/23.0 (0.2)	26.7 (4.1)/24.7 (0.3)
No. of DMF teeth	22.2 (9.4)/22.0 (0.2)	20.5 (11.0)/19.8 (0.4)	23.4 (9.0)/22.8 (0.2)	21.1 (11.9)/20.3 (0.3)
No. of sound teeth	8.8 (9.4)/10.0 (0.2)	10.5 (11.0)/12.2 (0.4)	7.6 (9.0)/9.2 (0.2)	9.9 (11.9)/11.7 (0.3)
No. of decayed teeth	0 (0.5)/1.0 (0.1)	0 (0.3)/0.8 (0.1)	0 (0)/0.4 (0.04)	0 (0)/0.3 (0.04)
No. of decayed and/or fractured teeth	0 (0.9)/1.2 (0.1)	0 (0.8)/1.1 (0.1)	0 (0.2)/0.6 (0.04)	0 (0.01)/0.5 (0.1)
No. of filled teeth	12.2 (9.9)/12.2 (0.2)	11.5 (10.4)/11.4 (0.3)	13.2 (10.0)/13.2 (0.2)	12.0 (10.0)/12.5 (0.2)
Periodontally examined	<i>n</i> = 1162	<i>n</i> = 609	<i>n</i> = 327	<i>n</i> = 746
No. of teeth with no pocketing	18.8 (15.4)/16.9 (0.3)	20.2 (15.1)/18.2 (0.5)	21.1 (14.0)/18.7 (0.3)	23.1 (10.8)/20.5 (0.4)
No. of teeth with any pockets ( $\geq 4$ mm)	2.7 (7.7)/5.6 (0.2)	2.7 (8.3)/5.6 (0.4)	1.0 (5.0)/3.7 (0.2)	1.0 (5.3)/3.7 (0.2)
No. of teeth with deep pockets ( $\geq 6$ mm)	0 (0.1)/0.9 (0.1)	0 (0)/0.7 (0.1)	0 (0)/0.5 (0.1)	0 (0)/0.4 (0.1)
Who age groups				
35- to 44-year-olds	<i>n</i> = 341	<i>n</i> = 112	<i>n</i> = 359	<i>n</i> = 134
No. of teeth	27.4 (2.9)/27.4 (0.2)	27.6 (1.24)/27.4 (0.5)	27.3 (5.1)/27.1 (0.2)	27.4 (1.1)/27.8 (0.2)
No. of DMF teeth	19.9 (9.6)/20.4 (0.3)	13.7 (11.2)/15.0 (0.8)	20.6 (8.1)/20.6 (0.3)	13.1 (7.0)/14.3 (0.4)
No. of decayed teeth	0 (0.3)/0.8 (0.1)	0 (0.4)/0.6 (0.1)	0 (0)/0.3 (0.1)	0 (0)/0.3 (0.1)
Periodontally examined	<i>n</i> = 341	<i>n</i> = 110	<i>n</i> = 355	<i>n</i> = 132
No. of teeth with no pocketing	22.8 (8.6)/21.0 (0.5)	23.6 (12.3)/20.6 (1.2)	24.4 (5.4)/23.0 (0.3)	25.9 (4.8)/24.3 (0.5)
No. of teeth with any pockets ( $\geq 4$ mm)	2.1 (6.2)/4.9 (0.4)	2.2 (7.7)/6.0 (1.1)	0.7 (4.0)/3.2 (0.3)	0 (3.0)/2.8 (0.5)
65- to 74-year-olds	<i>n</i> = 99	<i>n</i> = 100	<i>n</i> = 112	<i>n</i> = 128
No. of teeth	18.0 (15.4)/16.4 (0.9)	21.9 (11.2)/19.6 (1.1)	17.3 (15.8)/15.5 (0.9)	22.5 (13.9)/19.9 (0.7)
No. of DMF teeth	26.8 (6.9)/26.5 (0.5)	24.5 (7.3)/24.9 (0.5)	27.3 (6.2)/27.4 (0.4)	25.4 (6.1)/26.1 (0.4)
No. of decayed teeth	0 (1.1)/1.0 (0.1)	0 (0)/0.5 (0.2)	0 (0)/0.5 (0.1)	0 (0)/0.2 (0.1)
Periodontally examined	<i>n</i> = 91	<i>n</i> = 98	<i>n</i> = 105	<i>n</i> = 123
No. of teeth with no pocketing	7.8 (11.0)/9.2 (0.8)	14.5 (15.2)/13.3 (1.1)	8.8 (11.6)/11.3 (0.8)	17.5 (16.0)/16.0 (0.8)
No. of teeth with any pockets ( $\geq 4$ mm)	3.6 (9.9)/6.7 (0.7)	3.5 (6.9)/5.7 (0.6)	1.8 (5.5)/4.2 (0.6)	1.0 (5.2)/3.6 (0.4)

<sup>a</sup>Sampling weights were in 2000 were based on age, sex, living area and mother language and in 2011 age, sex, education, physical activity, use of alcohol, use of vegetables, size of household and body mass index.

interviews in 2013 was recently reported in the multi-national Survey of Health, Aging and Retirement in Europe (SHARE) in the Netherlands (27%) and in Austria (21%). Lowest prevalences in this survey were reported in Denmark, Switzerland (7%) and Sweden (3%) [34]. Results based on clinical findings but on a regional sample support low prevalence of edentulousness in Sweden; only 0.3% of those aged 40–70 years were edentulous in 2013 [15]. In Finland, the vast majority of dentate subjects had at least 20 teeth, which is in line with reports from other countries. For the 65- to 74-year-olds, however, the variation is wide: 86% in Denmark in 2008 [7], 61% in the United Kingdom in 2009 [21], 44% in Spain in 2010 [25] and 23% in Hungary in 2004 [4], while the Finnish figure was 57% in 2011. The unreported inclusion or exclusion of wisdom teeth may, however, cause bias in comparisons of findings between the countries.

In addition of higher number of teeth, better dental health was indicated by all other measures used in this study. The numbers of sound and untreated teeth are parameters that are seldom reported [12,21,35]. In this study concerning southern and northern Finland, the mean number of sound and untreated teeth increased whereas the number of filled teeth decreased the latter finding contradicting recent UK findings [36]. The mean numbers of DMF teeth decreased being for 35- to 44-year-olds in 2011 fairly similar to those in Denmark [7], Hungary [4], Austria [13] and Germany [35], but greater than those in the USA [24]. We used 32 teeth as the

basis for all indicators of dental conditions which may partly explain these differences. Unfortunately, the other reports do not give the basis for calculating their DMF-based indices. In addition, the occurrence of caries decreased the result for Finnish men being in line with findings from the UK data in 2009 [23] and with the regional data from Sweden in 2008 and 2013 [17]. Furthermore, the mean numbers of DT in Finland were almost the same as those reported from Germany [37], but slightly smaller than those reported from the UK [23] and Spain [25]; their data, however, included only coronal caries. For the Finnish adults, the means of DT were clearly smaller than in Hungary where the mean DT was 4.3 for 35- to 44-year-olds and 2.0 for 65- to 74-year-olds [4]. It has been suggested that burden of untreated caries is shifting from children to adults with one peak at age 70 years [38]. This was shown in local Swedish data where mean number of decayed surfaces increased among the oldest (those aged 85+ years) [17] but not yet in our study.

The changes in periodontal health seem to be parallel to those seen at the population level in the United Kingdom [23] and in the USA [24] and in the WHO age groups in Spain [25] and in Pomerania, Germany [39]. However, the most recent cross-sectional data sets from 2009–2012 show wide differences in the prevalence of no periodontal pocketing: 84% in Spain, 57% in the United Kingdom, 47% in Finland and 33% in Pomerania. For 35- to 49-year-olds in the USA, the proportion was 61% [32]. However, the extent and

severity of periodontal pocketing seem to be at a high level in Finland. Even so, comparisons between studies are complicated by the lack of a global consensus for describing disease severity and differences in, for example, the age groups used. Comparisons can be difficult even between surveys conducted in one country due to changes in examination protocols, for example change between partial and full-mouth examinations in the NHANES [2]. It has been estimated that a partial recording underestimate the prevalence and severity of periodontal disease [40,41]. However, the latest national study in the USA [31,32] offers good possibilities for comparison. Their study defined severe periodontal pocketing if at least 30% of teeth were affected. Our limit was 8+ teeth with PPD  $\geq$ 4 mm (indicating at least 32% of teeth affected) which thus corresponds well with their criterion. In the USA, 13% of participants belonged to this group, but 18% of women and 28% of men in Finland. With regard to severe pocketing, prevalence of those having teeth with PPD  $\geq$ 6 mm were higher in Finland than in the USA [31], in the United Kingdom [23], or in the other Europe including Eastern Europe [38].

A limitation of our survey is that the clinical data did not cover the whole country. However, the data did represent two large districts (northern and southern Finland) with various living conditions, and the baseline findings and their changes were estimated using data from the same areas in both surveys. The results shown in Table 1 support the reliability of the found changes of oral health during 11-years since mean age and gender or education level distributions of the participants in subpopulations (=southern and northern Finland) did not essentially differ from participants representing the whole country. This in spite of the fact that mean age in 2000 and distributions of educational levels both in 2000 and 2011 were statistically significantly different between the whole country and subpopulations. A further limitation is the low participation rate in the Health 2011 Survey, especially in the health examination; lowest participation rates were seen among youngest men. Nevertheless, the background information of the dropouts is available and was used in defining weights to correct population-level estimates. These weights were in 2000 were based on age, sex, living area and mother language and in 2011 age, sex, education, physical activity, use of alcohol, use of vegetables, size of household and body mass index [30]. According to Härkänen et al. [42], statistical methods based on weighting or multiple imputation provide quite accurate results when comparing the survey results to data obtained from national registers with the responses of the participants. Thus, the differences in the participation rates between the surveys caused most likely no systematic error to comparisons. As supposed, a slight increase of educational level evidently reflects a general development in a society. However, low participation rates in any survey are a true problem today. Those who did not attend the survey are probably persons with poorest oral health and thus the results of oral health in 2011 may be too optimistic. Hence, we need to be cautious while drawing any conclusions of the changes between the surveys.

Clinical dental examination in population-based surveys is challenging due to large populations, requiring much time and strict rules for data collection. The well-planned framework and a tested protocol, developed for the previous Finnish surveys in 1980 and 2000 [11,12] are strengths of our survey. The measurements in 2011 ensured full comparability with earlier data. The WHO has given instructions for clinical data collection and recordings in population-based studies and defined the age groups of importance for surveys with limited resources. Still, international comparisons of adults' dental and periodontal health remain complex or impossible because the recordings of clinical dental and periodontal findings vary from study to study. The use of full-mouth recordings instead of partial-mouth- or sextant-based recordings is a further strength of our survey, increasing the reliability of the data. All tooth surfaces and sites were examined, but because of the limited time allocated per participant the recordings were by tooth. Consequently, our method minimizes the bias caused by inter-correlation between the status of different surfaces and sites, which could have led to the slight overestimation of parameters, but our recording may underestimate especially the extent of the pocketing and decayed/fractured lesions. In addition, recall bias is not a concern since our results were based on clinical findings.

We used common validated indicators to describe dental and periodontal health and our main focus was on estimating treatment needs, not on exploring long-term history of caries or periodontal disease. Our findings of decayed and/or fractured teeth undoubtedly led to an underestimation of the need for restorative treatment since people normally visit a dentist to get fractures of a tooth or filling fixed as soon as they occur. This is seen in the restorative therapy for adults where replacing of fractured or otherwise failed fillings predominates in dentists' treatment procedures [43]. As regards periodontal treatment needs, our findings may to some degree overestimate the presence of active periodontitis, because our data on deepened pockets also include treated non-bleeding residual pockets.

## Conclusions

Changes in dental and periodontal health of adults were unambiguous and shown by a variety of indicators, each demonstrating positive changes in health conditions and treatment needs, with periodontal pocketing remaining a concern. The findings are in line with population-based reports from Europe and the USA and may reflect improvement in general living conditions more than everyday actions by the dental care service systems and levels of subsidization, which vary from country to country.

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## Disclosure statement

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

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