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ORIGINAL ARTICLE

Prevalence of dental caries and influencing factors, time trends over a 30-year period in an adult population. Epidemiological studies between 1983 and 2013 in the county of Dalarna, Sweden

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ABSTRACT

Objective: The aim of this study was to investigate the prevalence of dental caries in an adult population using four different cross-sectional studies over a 30-year period and to assess its possible associations with socio-economic and socio-behavioural factors.

Materials and methods: Four cross-sectional epidemiological studies were performed in the county of Dalarna, Sweden, in 1983, 2003, 2008 and 2013. Random samples of 1012–2244 individuals, aged 20–85 years, who answered a questionnaire about socio-economic and socio-behavioural factors, were radiographically and clinically examined.

Results: The proportion of individuals with at least one decayed surface (DS) was 58% in 1983 and significantly lower, 34% in 2008 ($p < 0.05$) and 33% in 2013; the mean number of DS was 2.0 in 1983 and 1.1 in 2013 in the age group 35–75 ($p < 0.05$). In the age group 85, the mean number of DS was 1.2 in 2008 and 2.4 in 2013. Adjusted for age and number of teeth, irregular dental visits, limited financial resources for dental care, smoking, education below university, male gender, daily medication and single living were positively and statistically associated with manifest caries.

Conclusion: The declining trend in the prevalence of manifest caries seems to be broken. In the oldest age group mean number of DS was higher in 2013 compared with 2008, indicating a possible beginning of an increase. This needs special attention as this group increases in the population, retaining natural teeth high up in age. Manifest caries was found to be associated with socio-economic and socio-behavioural factors.

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Introduction

Studies conducted in Sweden and other industrialized countries over recent decades have shown a decline in dental caries as measured by the decayed missing filled teeth (DMFT) index and the number of individuals without caries and restorations has increased.[1–3] Epidemiological studies indicate that socio-behavioural, environmental and socio-economic factors have a significant role in oral diseases such as dental caries. In a systematic review, low education, unemployment, low income and low social class were significantly associated with a greater occurrence of dental caries.[4] The association between low education and past or present dental caries has also been found in another systematic review and meta-analysis.[5] The evidence of a relationship between dental caries and smoking is weak.[6] Irregular dental care visits have been associated with higher scores of decayed teeth (DT) and missing teeth than regular visits.[7] The use of prescribed medicine has increased in most populations, especially among the elderly, and in Sweden the use of prescribed medicine increases by 3–4% every year and people aged 80 and over use an average of 5.8 prescribed medicines each.[8] Intake of drugs with hyposalivatory side-effects has been found to be a predictor for the incidence of dental caries.[9]

The incidence and effects of dental caries in children and adolescents have been thoroughly investigated, but caries experience among adults has received less attention. In a recent review, Kassebaum et al. [10] concluded that studies on the total number of DTs per person in a population and the proportion of adults with untreated caries are warranted. As the elderly population retains an increasing number of teeth, it is important to explore the risk and possible influential factors for dental caries among adults.

The aim of the present study was to investigate the prevalence of dental caries in an adult population over a 30-year period and to assess its possible associations with socio-economic and socio-behavioural factors using data from four epidemiological cross-sectional studies conducted in the county of Dalarna, Sweden.

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Materials and methods

Study design

Cross-sectional studies using questionnaires and clinical examinations including radiographs.

Sampling and study population

Every fifth year since 1983 cross-sectional studies have been performed in the county of Dalarna, Sweden, and data files were available for analysis for study years 1983, 2003, 2008 and 2013. Data for the study years 1988, 1993 and 1998, including 987, 1229 and 1298 individuals, respectively, in the age groups 35, 50, 65 and 75 were collected from written reports and are, therefore, presented only as frequencies and distributions. In 1983, 2003, 2008 and 2013 random samples of 1012, 1542, 1800 and 2244 individuals aged 20–85 and evenly distributed over six rural and urban geographical areas were selected from the Dalarna population register and invited to participate. In 1983 the sample was evenly distributed among the age intervals 20–39, 40–59 and 60–79. Data regarding age was available for the 912 individuals that responded to the questionnaire (353, 293 and 266 individuals in the age intervals, respectively), corresponding to 1%, 0.5% and 0.4% of the population in each age intervals. To best compare the investigations, 125 individuals aged 20–27 years were excluded and the remaining individuals were grouped into four age intervals with mean ages close to 35 ($n = 279$), 50 ($n = 242$), 65 ($n = 182$) and 75 ($n = 84$) years, corresponding to the age groups in the 2003 and 2008 surveys. The mean ages in the 1983 groups were 35.1 (28–42), 51.3 (43–59), 64.8 (60–70) and 74.2 (71–79). In 2003, 1542 individuals in the age groups 35 ($n = 412$), 50 ($n = 468$), 65 ($n = 355$) and 75 ($n = 307$) were selected, corresponding to 14% of the population in each age group. In 2008, the age group 85 was added and random samples corresponded to 11%, 10%, 10%, 16% and 26% of the population in each age group, respectively (360 individuals in each of the five age groups). In 2013, random samples of 204 individuals in each of the age intervals 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79 and 80–85 were selected. The sample was then divided into five age intervals: 30–41, 42–58, 59–71, 72–77 and 78–85, resulting in mean ages as close as possible to 35, 50, 65, 75 and 85 (35.2, 50.2, 65.2, 74.7 and 80.5, respectively). The sample corresponded to 0.6%, 0.3%, 0.4%, 1% and 1%, respectively, in the five different age intervals.

The 85-year-old age group was not included in study years 1983 and 2003. The comparisons between the study years 1983, 2003, 2008 and 2013 are, therefore, made for age groups 35, 50, 65 and 75. A separate analysis was made between the years 2008–2013 in the 85-year-old age group.

Procedure

All participants were invited by a mailing including a questionnaire and a pre-stamped envelope. Two reminders were sent at 3-week intervals. Potential participants were informed of the purpose of the study and told that a clinical and radiographic examination would be performed free of charge and that participation was voluntary. Written informed consent was obtained in 2008 and 2013.

The clinical examinations, including two-to-four bite-wing radiographs, were conducted by the participants' regular dental practitioners. Those not in regular contact with a dental practitioner were offered a referral to a practitioner of their choice.

Before data processing, all documents and radiographs were coded and personal identification details were deleted. This procedure was the same for all study years.

Instrument

Questionnaire variables

The number of questions increased over the study years from 29–74 and included items on demographics, education, marital status, attendance at dental care, financial resources for dental care, medicine and tobacco habits. In 2008 and 2013 more questions on general health and quality-of-life were added. *Educational level* was dichotomized into 'high education' (university or college of higher learning) and 'low education' (up to secondary school). *Marital status* was dichotomized into 'cohabiting with or without children'and 'living single with or without children'. *Dental care* was dichotomized into 'regular' (if the participant visited the dental service at least every second year) and 'irregular'. *Financial resources* were dichotomized into 'no changes in dental visits' and 'fewer dental visits or cheaper treatment alternatives due to limited financial resources'. *Daily medication* was dichotomized into 'no daily intake of prescribed medicine' and 'at least one prescribed daily medicine'. *Smoking* was dichotomized into 'no smoking' and 'current smoking'. *Use of moist snuff* (*Swedish snus*) was dichotomized into 'no snus use' and 'current snus use'.

Clinical examination

The clinical examinations included number of existing teeth (third molar excluded in study year 1983): *Intact teeth*—teeth with no restorations or dental caries were registered; *Filled surfaces*—five surfaces on molars and premolars and four surfaces on incisors and canines were registered if restored; *Dental caries*—all tooth surfaces were clinically and radiographically examined for primary caries (new caries lesions on surfaces with no restorations) and secondary caries (lesion adjacent to a filling) according to the criteria used by Gröndahl et al. [11] Only lesions extending into the dentine (i.e. manifest caries) were registered. Caries lesions on root surfaces were recorded according to the criteria used by Nyvad and Fejerskov.[12] A standardized protocol including thorough written instructions to take vertical bite-wing radiographs including examples was sent to the dental clinics performing the clinical assessments. Dental caries in the premolar and molar regions were also confirmed on bite-wing radiographs by two of the authors.

The study was conducted according to the Helsinki Declaration and was approved by the Research Ethical Review Board at Uppsala University, Uppsala, Sweden, in 2008 and 2013.

Statistical analysis

Data were analysed using IBM SPSS 21.0 Inc. (Chicago, IL). The mean values, frequencies, distributions and 95% confidence intervals (CI) were calculated. Statistical differences over time were determined by Chi^2 test, with Bonferroni correction. A p value of <0.05 was considered to indicate statistical significance. Multiple logistic regression was used to analyse the influence of socio-economic and socio-behavioural factors on dental caries.

The response rate for both the questionnaire and the clinical examination was 78% ($n = 787$) in 1983, 74% ($n = 1146$) in 2003, 64% ($n = 1158$) in 2008 and 51% ($n = 1133$) in 2013. The present study accounts for dentate individuals who both responded to the questionnaire and attended the clinical examination.

After excluding edentulous individuals, 61% ($n = 614$), 269, 198, 116 and 31 individuals in each of the age groups 35, 50, 65 and 75, were available for analysis in 1983. In 2003, 72% ($n = 1107$), 284, 347, 273 and 203 individuals in each of the four age groups were available. In 2008, 61% ($n = 1105$), 207, 246, 258, 230 and 164 individuals in the age groups 35, 50, 65, 75 and 85 were available and in 2013, 50% ($n = 1115$), 198, 335, 326, 140 and 116 individuals in each of the five age groups were available for analysis. The 125 individuals in the age group 20–27 excluded in the 1983 study did not differ socio-economically or in terms of dental caries from those included. For details regarding the non-respondents, see Edman et al. [13]

Results

Age groups 35–75

Caries prevalence

The proportion of individuals with at least one manifest caries lesion were 58% in 1983 and significantly lower, 40% in 2003 and 34% in 2008 ($p < 0.05$). In 2013 the proportion were 33%. The proportion in the different age groups and in the additional study years 1988, 1993 and 1998 are illustrated in Figure 1. The mean number of decayed surfaces (DS) were significantly lower in 2013 than in 1983 and the mean number of DT and DFS was significantly lower in 2013 compared to 2003 ($p < 0.05$). Data for DT and DFS were not available for study year 1983. Mean numbers of DS, DT, and DFS are presented in Table 1. The proportion of DS in relation to the total number of surfaces was significantly higher in 1983 (2.5%) than in 2003 (1.2%), 2008 (0.8%) and 2013 (1.2%, $p < 0.05$). The proportions in the different age groups are illustrated in Figure 2. The proportion of DT in relation to the total number of teeth was significantly higher in 2003 (4.3%) than in 2008 (2.9%) and 2013 (3.2%, $p < 0.05$). The proportions of DT in the different age groups are illustrated in Figure 3. The proportion of DFS in relation to the total number of surfaces was significantly higher in 2003 (35.3%) and 2008 (35.1) than in 2013 (31.0%, $p < 0.05$). The proportions in the different age groups are illustrated in Figure 4.

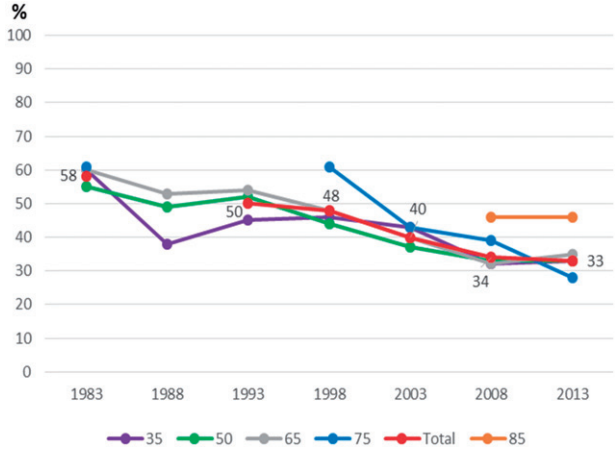

Figure 1. The proportion of individuals with at least one manifest caries lesion in the different study years across age groups. The total value in 1988 was not available.

Gender

In 2003 and 2013 significantly more men (44% and 39%) than women (37% and 27%) had manifest caries lesions ($p = 0.035$ and $p < 0.001$, respectively). In 1983, 60% of the men and 56% of the women had at least one manifest caries lesion (ns). The corresponding proportion in 2008 was 34% for both men and women.

Socio-economic and socio-behavioural factors

In all study years irregular dental visitors had significantly more manifest caries lesions than regular visitors (Table 2). In all study years except for 1983, limited financial resources were significantly correlated with manifest caries lesion. In 2003, 48% of those living alone had manifest caries lesions compared with 38% of those cohabiting with a partner ($p = 0.005$). In 2013 the corresponding proportion were 38% and 31% ($p = 0.037$). No correlations between marital status and manifest caries were found in 1983 and 2008. Individuals with education below university level had significantly more manifest caries lesions than those with university education in all study years (Table 2). Data regarding educational level were not available for study year 1983. In 2003, 52% of the smokers had manifest caries lesions compared with 38% of non-smokers ($p = 0.002$). No correlations were found in 1983, 2008 or 2013 (Table 2). No significant correlations with manifest caries lesions were found between snus users and non-users. Intake of prescribed medicine was reported by 24% in 1983, 36% in 2003, 48% in 2008 and 56% in 2013. No significant correlations were found between use of prescribed medicine and manifest caries lesions in the univariate analysis. Self-perceived xerostomia was reported by 28% in 1983 and 2003, 26% in 2008 and 46% in 2013. Xerostomia was not found to be correlated with daily medication or manifest caries lesions (not shown in Table 2).

Age group 85

Caries prevalence

The proportion of individuals with manifest caries was 46% in both 2008 and 2013 (Figure 1). The proportion of DS, DFS and DT in relation to the total number of surfaces and teeth

Table I. Mean number of decayed surfaces (DS), decayed teeth (DT) and decayed filled surfaces (DFS) in the different age groups and study years.

	DS				DT			DFS		
Age group	1983 Mean (SD)	2003 Mean (SD)	2008 Mean (SD)	2013 Mean (SD)	2003 Mean (SD)	2008 Mean (SD)	2013 Mean (SD)	2003 Mean (SD)	2008 Mean (SD)	2013 Mean (SD)
35	2.0 (2.8)[a]	1.4 (2.6)	0.8 (2.2)	0.9 (1.8)	1.2 (2.1)c	0.7 (1.6)	0.8 (1.4)	16.0 (10.5)[c]	12.2 (9.9)	11.6 (12.1)
50	2.0 (3.1)[a]	1.0 (1.9)	0.7 (1.5)	1.1 (3.3)	0.8 (1.5)	0.6 (1.1)	0.7 (1.5)	34.8 (17.1)[c]	28.8 (16.0)	25.9 (16.6)
65	2.1 (3.0)[a]	1.0 (1.8)	0.8 (2.2)	1.2 (3.2)	0.8 (1.3)	0.6 (1.2)	0.7 (1.4)	50.6 (19.9)[d]	49.7 (19.1)[d]	45.7 (18.6)
75	1.9 (3.3)[b]	1.2 (2.1)	0.8 (1.5)	0.9 (2.4)	0.9 (1.5)	0.6 (1.2)	0.6 (1.2)	47.9 (21.2)	49.2 (21.3)	48.8 (20.3)
Total	2.0 (2.9)[a]	1.1 (2.1)[b]	0.8 (1.9)	1.1 (2.9)	0.9 (1.6)[c]	0.6 (1.3)	0.7 (1.4)	36.3 (21.9)[d]	35.8 (23.0)[d]	32.8 (22.1)
85			1.2 (2.4)	2.4 (8.0)		0.9 (1.4)	1.0 (2.1)		45.4 (20.2)[d]	50.8 (24.5)

[a]Significant difference compared with 2003, 2008, and 2013.
[b]Significant difference compared with 2008.
[c]Significant difference compared with 2008 and 2013.
[d]Significant difference compared with 2013.

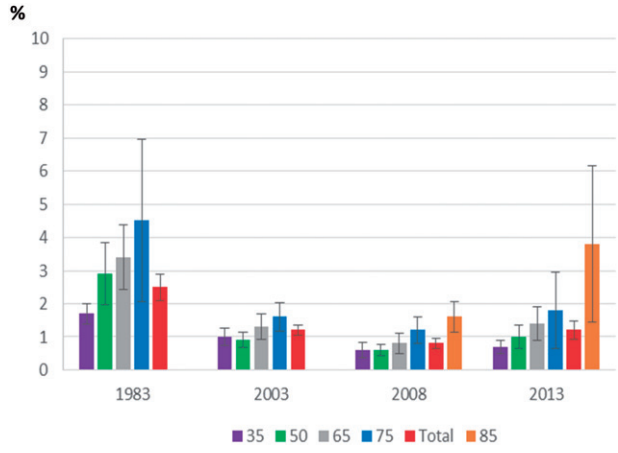

Figure 2. The proportion of decayed surfaces in relation to the total number of surfaces.

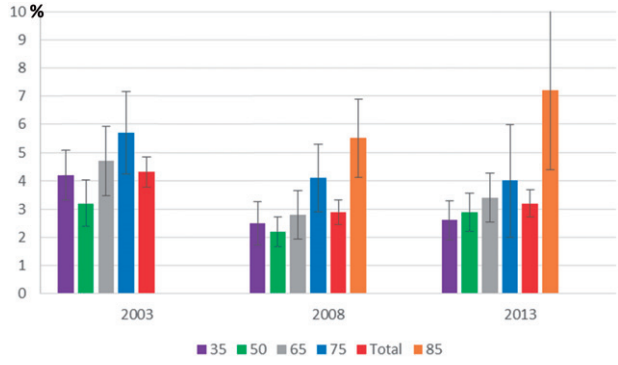

Figure 3. The proportion of decayed teeth in relation to the total number of teeth.

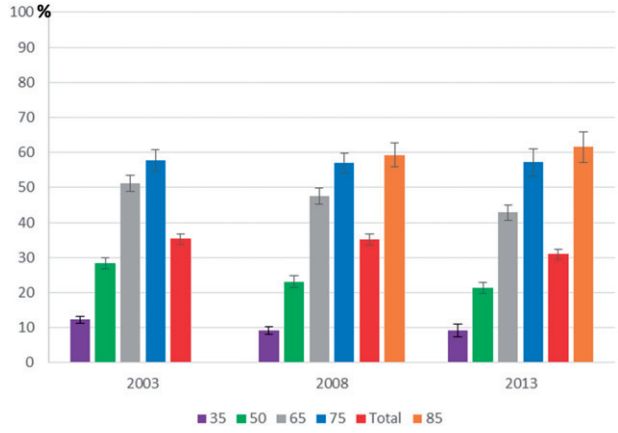

Figure 4. The proportion of decayed filled surfaces in relation to the total number of surfaces.

did not change significantly between 2008 and 2013 (Figures 2–4). The mean number of DFS was significantly higher in 2013 than in 2008 ($p = 0.044$, Table 1).

Gender

No gender differences were found in this age group and in study years 2008 and 2013.

Socio-economic and socio-behavioural factors

In 2008, 81% of irregular dental visitors had manifest caries lesions compared with 41% of regular visitors ($p = 0.001$). In 2013, no correlation was found between regularity of dental care visits and manifest caries lesions. Limited financial resources for dental care was correlated with manifest caries lesions in 2013 ($p = 0.008$, Table 2). Daily intake of prescribed medicine was reported by 83% in 2008 and 85% in 2013. Self-perceived xerostomia was reported by 35% in 2008 and 61% in 2013. No correlations with medication or xerostomia and manifest caries were found in the univariate analysis (not shown in table).

Multiple logistic regression analysis

Manifest caries lesions declined significantly between 1983 and 2013, even after adjustment for age, number of teeth and socio-economic and socio-behavioural factors. Irregular dental visits, financial limitations on dental care, smoking, male gender, daily medication and single living were significantly associated with at least one DS after adjustment for age group and number of teeth. When including education level in the model (study years 2003, 2008 and 2013), marital status became less evident, balancing on the border to significance (Table 3).

Discussion

In this series of cross-sectional studies, the prevalence of caries in an adult population was significantly lower in 2013 compared to 1983. The mean number of DT and the proportion of individuals with at least one DS were both significantly lower in 2013 than in 1983. Kassebaum et al. [10] showed in a recent review that 35% of the global population suffered from untreated caries in the permanent teeth in 2010. This

Table 2. Univariate analysis of the association between the proportion of individuals with manifest caries lesions (decayed surfaces >0) and dental visits, financial resources for dental care, marital status and level of education and smoking in the study years 1983, 2003, 2008 and 2013.

	1983				2003				2008				2013			
		Individuals with manifest caries				Individuals with manifest caries				Individuals with manifest caries				Individuals with manifest caries		
Age	Total % (*n*)	% (*n*)	% (*n*)	*p*-value	Total % (*n*)	% (*n*)	% (*n*)	*p*-value	Total % (*n*)	% (*n*)	% (*n*)	*p*-value	Total % (*n*)	% (*n*)	% (*n*)	*p*-value
Dental visits																
	Irregular	Regular	Irregular		Irregular	Regular	Irregular		Irregular	Regular	Irregular		Irregular	Regular	Irregular	
35	13 (36)	57 (133)	81 (29)	0.007	25 (70)	37 (80)	59 (41)	0.002	22 (45)	28 (45)	49 (22)	0.007	28 (54)	26 (37)	52 (28)	0.001
50	11 (21)	52 (91)	81 (17)	0.011	12 (40)	34 (103)	62 (25)	<0.001	13 (32)	30 (65)	50 (16)	0.028	22 (73)	28 (71)	49 (36)	0.001
65	22 (26)	57 (51)	69 (18)	0.250	9 (25)	38 (95)	60 (15)	0.035	7 (17)	31 (74)	53 (9)	0.058	12 (38)	33 (94)	50 (19)	0.036
75	29 (9)	64 (14)	56 (5)	0.675	11 (22)	42 (75)	59 (13)	0.120	5 (12)	37 (80)	67 (8)	0.043	7 (9)	26 (33)	44 (4)	0.236
Total	15 (92)	56 (289)	75 (69)	<0.001	14 (157)	37 (353)	60 (94)	<0.001	11 (106)	32 (264)	52 (55)	<0.001	18 (174)	29 (235)	50 (87)	<0.001
85									13 (21)	41 (58)	81 (17)	0.001	14 (16)	43 (42)	69 (11)	0.054
Financial resources for dental care																
	Limits	No limits	Limits		Limits	No limits	Limits		Limits	No limits	Limits		Limits	No limits	Limits	
35	1 (3)	60 (159)	100 (3)	0.157	29 (83)	35 (71)	60 (50)	<0.001	25 (51)	28 (43)	43 (22)	0.053	17 (33)	30 (50)	48 (16)	0.043
50	1 (2)	55 (107)	50 (1)	0.890	18 (62)	34 (98)	48 (30)	0.038	21 (51)	29 (55)	49 (25)	0.006	14 (46)	30 (85)	50 (23)	0.006
65	3 (3)	60 (68)	33 (1)	0.350	13 (36)	39 (93)	47 (17)	0.363	13 (34)	30 (67)	47 (16)	0.050	11 (36)	32 (92)	58 (21)	0.002
75	0	61 (19)	0	–	10 (20)	44 (80)	35 (7)	0.443	9 (21)	38 (77)	52 (11)	0.191	12 (17)	27 (33)	29 (5)	0.853
Total	1 (8)	58 (353)	62 (5)	0.813	18 (201)	38 (342)	52(104)	<0.001	17 (157)	32 (242)	47(74)	<0.001	13 (132)	30 (260)	49 (65)	<0.001
85									7 (11)	46 (67)	54 (6)	0.593	8 (9)	43 (44)	89 (8)	0.008
Marital status																
	Single	Cohab.	Single		Single	Cohab.	Single		Single	Cohab.	Single		Single	Cohab.	Single	
35	19 (51)	59 (128)	67 (34)	0.313	22 (63)	43 (96)	40 (25)	0.595	20 (40)	35 (58)	22 (9)	0.126	20 (40)	32 (50)	40 (16)	0.317
50	20 (39)	51 (81)	69 (27)	0.043	24 (83)	32 (83)	54 (45)	<0.001	17 (41)	31 (64)	42 (17)	0.203	20 (67)	31 (83)	39 (26)	0.252
65	28 (32)	60 (50)	59 (19)	0.988	21 (56)	36 (78)	57 (32)	0.004	24 (61)	32 (62)	34 (21)	0.666	25 (81)	31 (74)	46 (37)	0.013
75	58 (18)	62 (8)	61 (11)	0.981	32 (66)	45 (62)	39 (26)	0.430	29 (66)	37 (61)	44 (29)	0.343	34 (47)	30 (27)	23 (11)	0.435
Total	23 (140)	57 (267)	65 (91)	0.075	24 (268)	38 (319)	48 (128)	0.005	22 (208)	34 (245)	36 (76)	0.417	24 (235)	31 (234)	38 (90)	0.037
85									57 (93)	45 (31)	45 (42)	0.976	45 (51)	49 (31)	43 (22)	0.518
Level of education																
					Low	High	Low		Low	High	Low		Low	High	Low	
35					69 (196)	34 (30)	46 (91)	0.052	63 (128)	23 (17)	38 (48)	0.029	57 (111)	25 (21)	40 (44)	0.028
50					72 (247)	24 (24)	42 (104)	0.002	72 (178)	26 (18)	35 (63)	0.183	73 (242)	30 (27)	34 (81)	0.590
65					88 (239)	32 (11)	41 (99)	0.313	83 (213)	30 (13)	32 (69)	0.782	78 (254)	30 (21)	36 (91)	0.327
75					88 (176)	33 (8)	44 (78)	0.308	91 (208)	35 (7)	39 (82)	0.699	87 (118)	6 (1)	31 (37)	0.029
Total					78 (858)	30 (73)	43 (372)	<0.001	78 (727)	27 (55)	36 (262) 0.012		74 (725)	27 (70)	35 (253)	0.016
85									91 (144)	43 (6)	46 (66)	0.831	87 (99)	47 (7)	46 (45)	0.930
Smoking																
	Smoking	No smoking	smoking		Smoking	No smoking	smoking		Smoking	No smoking	smoking		Smoking	No smoking	smoking	
35	35 (94)	58 (101)	65 (61)	0.251	8 (22)	41 (106)	64 (14)	0.037	8 (17)	32 (60)	41 (7)	0.427	7 (14)	32 (59)	43 (6)	0.415
50	20 (40)	55 (87)	52 (21)	0.741	18 (61)	34 (98)	49 (30)	0.028	14 (35)	31 (65)	46 (16)	0.086	9 (30)	33 (99)	30 (9)	0.738
65	19 (22)	58 (55)	64 (14)	0.659	15 (42)	39 (89)	48 (20)	0.278	14 (36)	32 (69)	36 (13)	0.584	11 (37)	32 (93)	54 (20)	0.008
75	10 (3)	61 (17)	67 (2)	0.841	7 (14)	42 (78)	64 (9)	0.097	4 (8)	38 (82)	62 (5)	0.162	7 (10)	28 (36)	30 (3)	0.875
Total	26 (159)	57 (260)	62 (98)	0.336	13 (139)	38 (371)	52 (73)	0.002	10 (96)	33 (276)	43 (41)	0.060	9 (91)	32 (287)	42 (38)	0.054
85									1 (1)	46 (71)	0	0.356	4 (5)	46 (50)	40 (2)	0.797

accords with our study's finding of manifest caries in 33% of participants.

Although the mean number of DS was significantly lower in 2013 compared to 1983 there was no significant differences between 2008 and 2013, indicating that the declining trend seems to be broken. This needs to be confirmed in future studies. However, as the proportion of individuals with manifest caries was not higher in 2013 compared to 2008, it seems that individuals susceptible to dental caries may develop more lesions and that caries lesions are not evenly distributed.

Although oral health has improved over the past decades in Sweden, there are still disparities, mainly due to socio-economic differences.[14] In the present study, socio-economic and socio-behavioural factors were found to be associated with manifest caries lesions. This accords with other studies showing that the odds of having any caries lesions or caries experience were significantly greater among those with low education and low income.[5] In 1983, irregular dental visits were most prevalent in the higher age groups and living alone and becoming older, frailer and functionally dependent has been correlated with irregular dental visits.[15] However, for the other study years, irregular dental visits were most prevalent in the two youngest age groups.

The cost of dental care has increased steadily since 1983 and the present study found that self-reported limited financial resources for dental care were correlated with manifest caries in 2003, 2008 and 2013. There are social inequalities regarding self-reported refraining from seeking healthcare and dental care due to financial reason.[4,16] A decreased utilization of dental care services and increasing levels of socio-economic disadvantage has been found to be associated with worsened oral health.[17] In a recent Swedish oral health survey, people with lower socio-economic status were found to have poorer dental health and a tendency to under-estimate their need for dental care.[18] This provides additional evidence that socio-economic status influences oral health.

Daily medication was found in this study to have more than doubled from 1983 to 2013. It is well known that polypharmacy could cause hypo-salivation, which may, in turn, increase the risk of dental caries.[9,19] In the present study no association was found between manifest caries and daily medication or self-reported xerostomia in the univariate analysis. However, in the multiple logistic regression daily medication was associated with at least one DS, which seems to be a reasonable finding and is an observation of importance for dental professions.

The evidence of a relation between smoking and dental caries is poor and in a recent review evidence that found smoking to be associated with an increased risk for dental caries was regarded as weak.[6] In the present study smoking was associated with manifest caries in the multivariate analyses. Aleksejuniene et al. [20] found that smokers had higher DS scores, but lower DMFT scores than non-smokers in bivariate analysis. However, after adjustment for socio-economic and socio-behavioural factors and self-reported general health, the association between DS and smoking disappeared, indicating that other factors than smoking might be responsible for the association. In the present study, we have not been able to adjust for dietary habits and fluoride use, which could be possible confounding factors regarding the association between smoking and caries.

Table 3. Multiple logistic regression analysis with at least one decayed surface as dependent variable and socio-economic and socio-behavioral factors and survey year as independent variables.

	1983–2013[a] OR (95%CI)	2003–2013[b] OR (95%CI)
Dental visits		
Regular (ref)		
Irregular	2.08 (1.70–2.55)	2.03 (1.62–2.53)
Financial resources		
No limits (ref)		
Limits	1.51 (1.23–1.87)	1.50 (1.21–1.86)
Smoking		
No (ref)		
Yes	1.37 (1.12–1.69)	1.42 (1.11–1.81)
Education		
University (ref)		
Below university	–	1.36 (1.13–1.65)
Gender		
Female (ref)		
Male	1.32 (1.15–1.51)	1.35 (1.16–1.56)
Medication		
No (ref)		
Yes	1.23 (1.06–1.44)	1.24 (1.05–1.47)
Marital status		
Married/cohabitant (ref)		
Single living	1.19 (1.02–1.39)	1.18 (0.99–1.40)
Survey year		
1983	ref	
2003	0.44 (0.35–0.55)	ref
2008	0.33 (0.26–0.42)	0.75 (0.62–0.90)
2013	0.30 (0.24–0.38)	0.69 (0.57–0.84)
Nagelkerkés R^2	0.093	0.07

[a]All variables except education, included, adjusted for age and number of teeth.
[b]All variables included adjusted for age and number of teeth.

The extensive use of fluoride toothpaste, starting in the middle of the 1960s, has been proposed to be a major factor behind the reduction of caries.[21] Furthermore, a better understanding of the pathogenesis of dental caries, increased preventive efforts, as well as the methods to identify risk groups for the disease might have influenced lower incidence of caries over time. Preventive oral health programmes, especially in children and adolescents, focusing on oral hygiene and dietary habits, could result in improved oral health in older age, because fewer restorations are associated with fewer secondary carious lesions. Dental caries is regarded as largely preventable; using fluoride products and reducing sugar intake are important recommendations.[22–24] Dietary habits were not investigated in the present study, but may be an important independent factor. Despite declines in caries among children, it has been found that caries levels increase with age and remain problematic in adults.[25] As life expectancy increases and tooth loss decreases it is important to promote oral health not only in children and adolescents, but also in the adult population and to encourage the adult population to continue regular dental attendance.

In 1983, when the first epidemiological study was performed in the county of Dalarna, it was decided that the clinical examinations should take place in the patients' regular dental office. To be able to compare the study in 1983 with subsequent studies, the same methodology was used in the

upcoming study years. This resulted in several different individuals performing the clinical examinations, which may have affected the clinical variable outcomes. However, comprehensive written instructions and illustrations of the different clinical variables to be recorded were provided and these clinical variables are used in the ordinary dental examination that dentists are trained for. The prevalence of manifest caries lesions was verified, on the bite-wing radiographs in the premolar and molar region, by two trained examiners from the project group who reviewed all radiographs. The results are in agreement with other studies, using similar study samples and methods,[2,26] indicating that the diagnostic criteria for manifest caries were satisfying.

In this study, the non-respondent rate increased over the study years. The non-response rate for both the questionnaire and clinical examination varied from 22% in 1983 to 49% in 2013. This is a limitation in the present study and might partly be an explanation for the reduction in caries prevalence. It is reasonable to expect that the non-responders were no healthier than participants, as studies have shown that non-respondents are generally less healthy than participants in health investigations [27–30] and it is unlikely that the prevalence of dental caries in the present study has been over-estimated. Non-respondents have also been found to be more common in economically disadvantaged groups and among individuals with low education.[30]

In the univariate analysis there were very few individuals in some of the sub-groups, which may be a reason why no significant results could be found in 1983, specifically in regard to limited financial resources.

The strengths of the present study were the sample selection, representing both rural and urban areas in the same county and the consistent methodology used in all study years.

In conclusion, the prevalence of dental caries in the adult population of the county of Dalarna has dramatically declined between 1983–2013. Socio-economic and -behavioural factors and smoking were correlated to manifest caries lesions. In the oldest age group DS was higher in 2013 than in 2008. This needs special attention as this group increases in the population. It is important that dental healthcare is promoted across the entire life span and that scientific evidence are presented in an understandable way for the public, other professions and decision-makers.

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Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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