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Oral health in a life-course: Birth-cohorts from 1929 to 2006 in Norway

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Objectives: The purpose of the work was to study the influence of the oral health environment at age 10, of adolescent and adulthood dental behaviours and of social status on oral health of three birth-cohorts in 1983 and two of the three birth-cohorts in 2006 in Norway. ***Methods:*** The material comprised data from random samples of three birth-cohorts living in the counties of Sør- and Nord-Trøndelag in 1983. The birth-cohorts were 1929-1938, 1939-1948 and 1959-1960. In 2006 two samples were drawn from the 1929-1938 and 1959-1960 birth-cohort. The data collection comprised standard clinical measurements and self-administered questionnaires. The early oral health environment and social status and gender were related to oral health in 1983 by multiple regressions. The impact of social status was studied in combined datafiles from 1983 and 2006. ***Results:*** The oral health environment in childhood was important for adults' oral health. The attention from parents and the local environment lead to a better oral health outcome in adulthood. Social status affected choices leading to better oral health. Regular dental visits were important especially for the eldest birth-cohort. Good oral health behaviours early and during adulthood were also important for oral health. Judged by number of tooth surfaces the difference between social status groups had not increased by 2006. ***Conclusions***: A life-course perspective provides an opportunity to understand oral health over time. The present study supports the assumption that oral health is continuously exposed to environmental and behavioural risks that lead to accumulated diseases in the dental tissues.

Key words: *Life-course, oral health, social status*

Introduction

Viewing health and disease in life-course perspective has gained scientific interest recently (Kuh and Ben-Shlomo, 1997). Panel studies are scarce but other designs come close to being able to follow health and disease through life (Kuh and Ben-Shlomo, 1997). There are three major perspectives in life-course research: One line emphasises the importance of life-style and deprivation in childhood for adult chronic disease. This research investigates environmental conditions and experiences through pre-natal life, infancy, childhood and adolescence that may make individuals more susceptible to developing adult chronic disease. Pearce *et al.* (2004) studied the effect of birth-weight, early diet, use of comforter and social status on oral health of young adults, but found only effect of social status in the expected direction. Nicolau *et al. (*2003; 2007*)* found a relationship between several biological factors and caries among adolescents. A second line of research assumes biological programming during critical periods of development either during pregnancy or in early life (Barker, 1994). A third line of research suggests an accumulation of risk through the life course. Accumulation of risk is different from programming in that it does not require the notion of a critical period. This approach explicitly places more emphasis on a greater range of biological and social experiences in childhood, adolescence and in early adulthood than either the life style or programming models. There are reasons to believe that adult oral health is affected through a range of life-course mechanisms. The present study leans towards the third perspective arguing that oral health is continuously exposed to environmental and behavioural risks that lead to accumulated plaque in the mouth and diseases in the dental tissues (Fejerskov and Kidd, 2008).

A number of studies have described oral health in repeated cross-sectional studies (Kelly *et al.*, 2000; Krustrup *et al.*, 2008; Schuller and Holst, 1998). These studies provide valuable information about background related changes in oral health conditions at certain points of time. Edentulousness is less common now than 30 years ago (Petersen *et al.*, 2004; Holst 2008). The main explanations for this are improved standard of living, availability of fluoride toothpaste and more accessible dental services. Despite the improvement, social status still affects oral health during the life course, even though recent research indicates that this relationship has become weaker in some countries (Holst, 2008). There is reason to believe that avoiding edentulousness and maintaining oral health requires a life-long attention to healthy diet, oral health education, oral hygiene and preventive dental services. The present paper examines the influence of the oral health environment at age 10, of adolescent and adulthood dental behaviours and of social status on oral health of three birth-cohorts in 1983 and two of the three birth-cohorts again in 2006 in Norway. This unique possibility was made possible through a careful design of a series of cross-sectional studies in Trøndelag, Norway.

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Material and methods

The material comprised data from independent random samples of three birth-cohorts living in the counties of Sør- and Nord-Trøndelag in 1983. The birth-cohorts were 1929-1938, 1939-1948 and 1959-1960, and they were 45-54-, 34-44 and 23-24-years old in 1983 (Table 1, sample a). In 2006 two samples were drawn from the 1929-1938 and 1959-1960 birth-cohort in Nord-Trøndelag only, who were then 67-78-year-old and 46-47-year old (Table 1). The age specific sample size for each of the participating counties were 500 in 1983 and was reduced to 250 in 2006 because of limited economic resources. The sample in the two-year age-group 46-47 was 100 people.

The methods of data collection comprised standard clinical measurements and self-administered questionnaires (Bærum *et al.*, 1985; Schuller and Holst, 1998). In 1983 and in 2006 ten and two calibrated dental teams, respectively, collected the data. Two senior researchers (DH and AAS) followed and guided the procedures in order to secure standardised conditions and comparability between the surveys. The first Trøndelag study in 1973 started as part of the first WHO International Collaborative Study survey (Arnljot *et al.*, 1985). The study was also repeated in 1994 but not reported here. Calibration exercises were conducted each study year. Calibration was performed for paired examiners and intra-examiner variability was low for the DMF index ($r>0.92$). Inter-examiner agreement was exercised until $r>0.85$ between all pairs, and the results otherwise found satisfactory (Bærum *et al.*, 1985; Holst *et al.*, 2007). The examinations took place at the public dental clinics of the South- and Nord-Trøndelag counties. Permission was granted by public authorities and by the participants' informed consent. All necessary permissions were given throughout the study period and by the participants' informed consent. In 2006 the study was approved by the Middle of Norway Regional ethical committee and approved by the Norwegian Council of Research.

In the present study the outcome variables were number of sound teeth and surfaces (ST, SS) and sound + filled teeth and surfaces (SFT, SFS) and DMFT and DMFS index. DMFT and DMFS are the sums of DT/S, MT/S and FT/S, where DT/S is defined as the number of teeth/surfaces with primary and secondary caries, including root and coronal caries. Only caries with a distinguishable break in the surface was recorded. Missing surfaces is the number of missing tooth surfaces irrespective of cause. FS is the number of surfaces filled, both root and coronal restorations, including all types of filling materials and crowns. The clinical examination comprised recording of the condition of the visible part of the tooth. The analyses were based on 28 teeth excluding third molars.

In the first part of the analysis, 12 questions that were asked about oral health environment at age 10 in 1983 are presented (Table 2). The questions comprised whether the families had rules for eating sweets, tooth brushing habits, advice about oral health from teachers, school nurse/medical doctor and school dentist, fathers and mothers dental status, visits to a dentist during preschool and school age, parents control of tooth brushing, use of toothpicks and dental floss. Advice from teachers, school nurse/medical doctor and school dentist were collapsed into an index called advice about oral health (Table 2, column 3). Father's and mother's dental status were added to parents' dental status and dummy variables constructed (Table 2, column 4). Visits to a dentist during pre-school and school age were summarised to yearly and less often. The questions regarding whether the families had rules for eating sweets and tooth brushing habits were combined into parents attention and dummy variables constructed. Gender was included in the meaning of a social construct assuming females to be more engaged in health and oral health behaviours. Also length of education was considered an indicator of social resources in young adulthood. Length of education was divided into four quartiles: the 1st quartile had the shortest education and the 4th, the longest. Using quartiles eliminates the problems arising from changes over time in the length of education at the population level. Length of education was transformed into dummy variables (Table 2, column 4). Four questions on oral hygiene practices (1983) were added to the oral health behaviour index and dummy variables constructed.

In the first part of the analysis the early oral health environment and social status and gender were related to oral health variables in 1983 by multiple regressions. Since all the dependent variables were measured on the same scale (tooth surfaces), the regression coefficients can be interpreted directly as effects of the independent variables in number of surfaces. For the second part of the analysis the data files from 1983 and 2006 were

Table 1. Trøndelagsstudies. Samples in 1983 and 2006 according to birth-cohort and age. Participation in percent

		1983 a		*1983 b*		*2006*	
Birth-cohort	*Age*	*n*	*%*	*n*	*%*	*n*	*%*
1959-1960	23-24	1000	84	500	81		
	46-47					100	90
1929-1938	35-44	1000	82	500	80		
	45-54	1000	74	500	72	350	71
	68-77					250	61

1983 a: The sample includes Nord- and Sør-Trøndelag
1983 b: The sample includes Nord-Trøndelag

Table 2. Variables, categories, indices and analytical categories

Variables	*Categories and coding*	*Additive indices*	*Analytical categories/dummy variables*
Rules for sweet consumption	Yes (1) no (0)		
Toothbrushing habits	Twice a day (1) Once or less (0)		
Advice from teacher	Yes (1) no (0)	Advice about oral health	
Advice from doctor/nurse	Yes (1) no (0)	Advice (1-3)	Advice (1)
Advice from school /district dentist	Yes (1) no (0)	No advice (0+0+0)	No advice (0)
Father's dental status	Many teeth (2), few (1) none (0)	Parents' dental status	
Mother's dental status	Many teeth (2), few (1) none (0)	Many (4)	Dummy parents' dental status many
		Few (1-3)	Dummy parents'dental status few
		None (0)	Reference category
Visited a dentist pre school	Yearly (2) a few times (1) never (0)	Dental care at age 10	
Visited a dentist during school	Yearly (2) a few timel (1) never (0)	Yearly (4)	Yearly (1), Not yearly (0)
		A few times (1-3)	
		Never (0)	
Parents controlled toothbrushing	Often/daily (2) a few times (1) never (0)	Parents' attention	
Used toothpicks	Often/daily (2) a few times (1) never (0)	Daily (5-6)	Dummy parents attention daily
Used dental floss	Often daily/ (2) a few times (1) never (0)	A few times (1-3)	Dummy parents attention a few times
		Never (0)	Reference category
Gender	Female (1) Male (0)		
Length of education	Highest quartile (3)		Dummy highest quartile
	Second highest quartile (2)		Dummy second highest quartile
	Second lowest quartile (1)		Dummy second lowest quartile
	Lowest quartile (0)		Reference category
Regular dental visits last three years	Regular each year (1)irregular (0)		
Brushed yesterday	Yes (1) No (0)	Oral health behaviour	
Used dental floss yesterday	Yes (1) No (0)	Good (4)	Dummy oral behaviour good
Used toothpicks yesterday	Yes (1) No (0)	Middle (2-3)	Dummy oral behaviour middle
Had sweets yesterday	Yes (1) No (0)	Bad (0-1)	Reference category

Table 3. Descriptive statistics for independent variables in 1983. Sample a. Percentage

	Age in 1983		
	23-24 year	*35-44 year*	*45-54 year*
Oral health environment at age 10			
Had rules for sweet consumption	29.4	20.4	14.4
Toothbrushing twice per day	73.0	64.0	59.4
Got advice about oral health	98.2	70.1	53.8
Parents' many teeth	72.4	47.0	47.4
Dental care yearly	19.3	6.1	3.7
Parents' attention high	34.2	12.4	6.8
Behaviour in 1983			
Regular dental visits	65.8	69.4	63.7
Oral health behaviour good	23.8	15.2	11.0

Table 4. Dental variables in 1893 and 2006. Mean and standard deviation (sd) (basis 124 tooth surfaces, 28 teeth)

			SS		*DS*		*FS*		*MS*		*DMFS*	
	Age-group	*n*	*Mean*	*sd*	*Mean*	*sd*	*Mean*	*sd*	*Mean*	*sd*	*Mean*	*sd*
1983*	23-24	773	84.10	17.41	1.09	2.52	37.89	16.05	4.89	7.34	43.89	17.36
	35-44	773	48.54	21.51	2.25	6.23	48.64	22.86	28.55	30.77	79.45	21.51
	45-54	675	35.11	24.24	2.19	5.38	37.02	27.30	53.66	42.51	92.88	24.24
2006	46-47	96	79.08	21.02	0.80	1.90	38.59	16.73	5.38	7.20	44.77	18.83
	68-77	150	33.02	22.02	1.61	3.31	39.53	25.71	44.16	36.53	85.29	20.17

* Sample a

combined to study whether the impact of social status changed during the period. Multiple regression was used and the level of significance was p=0.05. Associations nearly reaching significance (0.07>p>0.05) are shown.

Results

The distributions of the independent variables according to age-groups and the means and standard deviations of dependent variables are shown in Table 3 and 4. Table 3 shows how the environment at age ten varied between the age-groups. Table 4 shows the variation between the age-groups in the condition of the tooth surfaces.

Tables 5-7 show how the early oral health environment, the social variables and the oral health behaviours each and combined (R^2) affected oral health in the age-groups in 1983.

Birth-cohort 1959-1960, 23-24 years in 1983: Table 5 shows the impact of the independent variables on the outcome variables. Having positive oral health behaviours at age ten increased the likelihood of more sound surfaces (SS),more filled surfaces (FS) and more surfaces with caries experience (DMFS) at age 23-24. If parents had many own teeth the 23-24-years-olds had 5.0 more sound surfaces (SS) and 5.0 fewer surfaces with caries experience (DMFS). Length of education was statistically significantly related to the D-M-F-S variables in the expected direction. Regular dental care was related to mean number of surfaces with untreated decay (DS). Good oral health behaviour was statistically significant related to more sound surfaces (SS) and fewer filled surfaces (FS). The variables in the model explained from 4-13 % of the variation in the dependent variables.

Birth-cohort 1939-1948, 35-44 years in 1983: Table 6 shows that parents' dental status and yearly dental visits at age ten had a statistically significant impact on several of the oral health variables. Having parents with many of their own teeth the 35-44 year olds had more functional surfaces (SFS), fewer missing surfaces (MS) and surfaces with caries experience (DMFS). Women had fewer sound surfaces (SS) and more filled surfaces (FS) and DMFS than men when they were 35-44-years-old in 1983. The longer the education, the better the values of the oral health indicators were; the differences between the quartiles of education were big. Dental care last year had a statistical significant influence on DS, SFS, MS and FS. The explained variation varied from 11 – 27 %.

Birth-cohort 1929-1938, 45-54 years in 1983: Table 7 shows that parents' dental status at age ten years had a statistically significant effect on the oral health variables. In addition tooth brushing and dental care at age 10 had a significant effect on untreated caries (DS). Women had fewer sound surfaces (SS), less untreated decay (DS) plus more filled (FS) and DMFS than men. Length of education had a significant effect on all oral health variables except untreated caries (DS). Oral health behaviour had a similar effect, while regular dental care also affected untreated caries (DS).

Table 5. Relationship between DMFS and life-course variables and indices. Multiple regression. Birth-cohort 1959-60 in 1983.

Variables	*Oral health*				*Untreated disease*				*Treated disease*			
	SS		*SFS*		*DS*		*FS*		*MS*		*DMFS*	
	Coefficient	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*
Intercept	18.46	2.70	17.95	3.99	8.19	0.82	6.61	2.82	104.70	4.03	109.54	2.70
At age 10												
Rules for sweet consumption	-4.20	2.85	-7.65 ^	4.20	1.35	0.79	-1.68	2.72	6.80	4.24	4.20	2.85
Toothbrushing habits	-0.01	2.26	2.41	3.34	-1.51 *	0.65	3.51	2.25	-1.09	3.37	0.01	2.26
Advice about oral health	0.47	1.73	0.91	2.55	-0.30	0.48	0.89	1.65	-6.86	2.57	-0.47	1.73
Parents dental status few teeth	3.45	2.29	5.15	3.38	-0.78	0.65	0.69	2.25	-4.75	3.42	-3.45	2.29
Parents dental status many teeth	5.86 *	2.26	8.53 *	3.34	-0.79	0.64	1.65	2.22	-8.13 *	3.37	-5.86 *	2.26
Dental care at age 10	-7.91	3.59	1.45	5.29	2.06 *	0.94	1.30	3.24	-3.56	5.34	0.79	3.59
Parents' attention a few times	-0.02	2.06	1.94	3.04	0.69	0.56	1.68	1.95	-2.62	3.07	0.02	2.06
Parents' attention daily	0.76	3.78	6.12	5.57	-0.02	1.03	3.95	3.54	-6.47	5.63	-0.76	3.78
Early adult age												
Gender	-8.24 *	1.86	-3.47	2.74	-1.27 *	0.52	7.39 *	1.80	5.50 ^	2.76	8.24 *	1.86
Education-second lowest quartile	3.65	2.23	8.35 *	3.29	-0.76	0.64	5.11 *	2.22	-7.64 *	3.32	-3.65	2.23
Education-second highest quartile	4.68 ^	2.58	19.27 *	3.81	-0.52	0.73	17.50 *	2.51	-18.81 *	3.84	-4.68 ^	2.58
Education- second highest quartile	13.36 *	2.48	32.93 *	3.66	-0.93	0.67	18.53 *	2.32	-32.32 *	3.69	-13.36 *	2.48
Last year												
Regular dental care	10.17 *	1.88	36.16 *	2.78	-3.23 *	0.56	19.92 *	1.92	-34.66 *	2.81	-10.17 *	1.88
Oral health behaviour middle	8.58 *	2.32	15.52 *	3.42	-0.94	0.67	4.45 *	2.32	-15.47 *	3.45	-8.58 *	2.32
Oral health behaviour good	9.10 *	3.16	16.56 *	4.65	-0.46	0.90	4.70	3.09	-16.83 *	4.70	-9.10 *	3.12
R2	0.191 ^p=0.070		0.434 ^p=0.069		0.135		0.388		0.415 ^p=0.070		0.191 ^p=0.070	

* = p< 0.05
^ = 0.05< p< 0.07

Table 6. Relationship between DMFS and life-course variables and indices. Multiple regression. Birth-cohort 1939-1948 in 1983

Variables	*Oral health*				*Untreated disease*				*Treated disease*			
	SS		*SFS*		*DS*		*FS*		*MS*		*DMFS*	
	Coefficient	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*
Intercept	37.86	2.77	58.28	3.77	7.52	0.81	24.14	2.61	62.96	3.70	90.14	2.77
At age 10												
Rules for sweet consumption	0.45	2.35	-1.87	3.20	-0.07	0.67	-1.83	2.16	2.01	3.14	-4.53	2.35
Toothbrushing habits	-0.38	2.08	-3.57	2.84	-0.61	0.60	-2.94	1.93	4.26	2.79	0.38	2.08
Advice about oral health	1.84	1.66	-0.38	2.26	-0.08	0.47	-2.15	1.53	0.40	2.22	-1.84	1.66
Parents dental status few teeth	-0.12	2.14	2.59	2.92	1.28 *	0.61	1.84	1.98	-3.99	2.86	0.12	2.14
Parents dental status many teeth	3.94 *	2.05	6.25 *	2.80	0.63	0.59	1.65	1.89	-6.97 *	2.74	-3.94 *	2.05
Dental care at age 10	-7.60 *	3.32	-1.06	4.53	0.87	0.93	5.58 ^	3.01	0.07	4.44	7.60 *	3.32
Parents' attention a few times	-0.59	1.89	2.11	2.58	-0.03	0.54	2.93	1.74	-1.96	2.53	0.59	1.89
Parents' attention daily	0.21	3.23	1.26	4.40	-0.06	0.92	0.77	2.97	-1.17	4.31	-0.21	3.23
Early adult age												
Gender	-7.23 *	1.66	-1.06	2.26	-0.79	0.47	6.31 *	1.52	1.87	2.21	7.23 *	1.66
Education-second lowest quartile	5.49 *	2.06	10.95 *	2.82	-1.06	0.59	4.78 *	1.91	-10.07 *	2.76	-5.49 *	2.06
Education-second highest quartile	6.78 *	2.14	20.97 *	2.92	-1.65 *	0.61	13.04 *	1.97	-19.54 *	2.86	-6.78 *	2.14
Education- second highest quartile	11.98 *	2.26	27.80 *	3.08	-1.55 *	0.64	14.60 *	2.07	-26.50 *	3.02	-11.98 *	2.26
Last year												
Regular dental care	2.58	1.74	17.38 *	2.38	-4.73 *	0.50	12.97 *	1.62	-13.09 *	2.33	-2.58	1.75
Oral health behaviour middle	6.43 *	2.28	14.05 *	3.11	-0.65	0.66	6.88 *	2.13	-13.60 *	3.05	-6.43 *	2.28
Oral health behaviour good	3.15	2.86	15.72 *	3.90	-1.11	0.83	12.56 *	2.66	-14.76 *	3.83	-3.15	2.86
R2	0.11		0.26		0.17		0.27		0.22		0.11	
							^p=0.064					

* = p< 0.05
^ = 0.05< p< 0.07

Table 7. Relationship between DMFS-and life-course variables and indices. Multiple regression. Birth-cohort 1929-38 in 1983

Variables	*Oral health*				*Untreated disease*				*Treated disease*			
	SS		*SFS*		*DS*		*FS*		*MS*		*DMFS*	
	Coefficient	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*
Intercept	18.46	2.70	17.95	3.99	8.19	0.82	6.61	2.82	104.70	4.03	109.54	2.70
At age 10												
Rules for sweet consumption	-4.20	2.85	-7.65 ^	4.20	1.35	0.79	-1.68	2.72	6.80	4.24	4.20	2.85
Toothbrushing habits	-0.01	2.26	2.41	3.34	-1.51 *	0.65	3.51	2.25	-1.09	3.37	0.01	2.26
Advice about oral health	0.47	1.73	0.91	2.55	-0.30	0.48	0.89	1.65	-6.86	2.57	-0.47	1.73
Parents dental status few teeth	3.45	2.29	5.15	3.38	-0.78	0.65	0.69	2.25	-4.75	3.42	-3.45	2.29
Parents dental status many teeth	5.86 *	2.26	8.53 *	3.34	-0.79	0.64	1.65	2.22	-8.13 *	3.37	-5.86 *	2.26
Dental care at age 10	-7.91	3.59	1.45	5.29	2.06 *	0.94	1.30	3.24	-3.56	5.34	0.79	3.59
Parents' attention a few times	-0.02	2.06	1.94	3.04	0.69	0.56	1.68	1.95	-2.62	3.07	0.02	2.06
Parents' attention daily	0.76	3.78	6.12	5.57	-0.02	1.03	3.95	3.54	-6.47	5.63	-0.76	3.78
Early adult age												
Gender	-8.24 *	1.86	-3.47	2.74	-1.27 *	0.52	7.39 *	1.80	5.50 ^	2.76	8.24 *	1.86
Education-second lowest quartile	3.65	2.23	8.35 *	3.29	-0.76	0.64	5.11 *	2.22	-7.64 *	3.32	-3.65	2.23
Education-second highest quartile	4.68 ^	2.58	19.27 *	3.81	-0.52	0.73	17.50 *	2.51	-18.81 *	3.84	-4.68 ^	2.58
Education- second highest quartile	13.36 *	2.48	32.93 *	3.66	-0.93	0.67	18.53 *	2.32	-32.32 *	3.69	-13.36 *	2.48
Last year												
Regular dental care	10.17 *	1.88	36.16 *	2.78	-3.23 *	0.56	19.92 *	1.92	-34.66 *	2.81	-10.17 *	1.88
Oral health behaviour middle	8.58 *	2.32	15.52 *	3.42	-0.94	0.67	4.45 *	2.32	-15.47 *	3.45	-8.58 *	2.32
Oral health behaviour good	9.10 *	3.16	16.56 *	4.65	-0.46	0.90	4.70 *	3.09	-16.83 *	4.70	-9.10 *	3.12
R2	0.191 ^p=0.070		0.434 ^p=0.069		0.135		0.388		0.415 ^p=0.070		0.191 ^p=0.070	

* = p< 0.05
^ = 0.05< p< 0.07

Table 8. Relationship between DMFS variables and independent variables. Combined datafile 1983 and 2006. Birth-cohort 1959-1960

Variables	*Oral health*				*Untreated disease*				*Treated disease*			
	SS		*SFS*		*DS*		*FS*		*MS*		*DMFS*	
	Coefficient	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*
Intercept	73.24	2.97	117.84	1.42	4.47	0.42	44.37	2.68	5.92	1.23	54.76	2.86
Gender	0.36	1.81	-1.23	0.89	-0.68 *	0.26	-1.09	1.63	1.47 ^	0.75	-0.30	1.74
Regular dental care	-0.61	2.05	-2.24	0.96	-0.74 *	0.29	0.14	1.85	1.01	0.85	0.41	1.97
Education-second lowest quartile	5.09	2.79	3.16 *	1.3	-1.73 *	0.4	-1.97	2.52	-1.42	1.16	-5.11 ^	2.69
Education-second highest quartile	1.06	3.00	2.65 ^	1.39	-1.54 *	0.43	1.49	2.71	-1.03	1.25	-1.08	2.89
Education-highest quartile	11.84 *	2.95	6.40 *	1.37	-2.08 *	0.42	-5.64 *	2.67	-4.21 *	1.22	-11.93 *	2.84
Oral behaviour middle	5.88 *	2.45	0.91	1.23	-1.12 *	0.35	-4.91 *	2.22	0.12	1.02	-5.91 *	2.36
Oral behaviour good	6.74 *	2.81	1.22	1.42	-1.30 *	0.4	-4.67 ^	2.54	-0.13	1.17	-6.09 *	2.71
Year	3.57	4.55	-3.35	2.55	-1.11	0.65	-2.26	4.11	-1.69	1.89	-5.06	4.38
Interact. Year/second lowest q.	-14.55 *	5.84	-2.55	3.3	1.08	0.83	7.43	5.28	1.66	2.43	10.16	5.63
Interact. Year/second highest q.	-1.47	6.2	-2.54	3.88	0.22	0.88	-2.57	5.6	-0.91	2.57	3.26	5.97
Interact. Year/ highest q.	-1.10	6.68	-3.71	3.78	0.66	0.95	-3.40	6.03	3.96	2.77	1.18	6.43
R2	0.11		0.12		0.16		0.06		0.05		0.10	
			^p=0.058				^p=0.067		^p=0.051		^p=0.058	

* = p< 0.05
^ = 0.05< p< 0.07

Table 9. Relationship between DMFS- and independent variables. Combined datafiles 1983 and 2006. Birth-cohort 1929-1938

Variables	*Oral health*				*Untreated disease*				*Treated disease*			
	SS		*SFS*		*DS*		*FS*		*MS*		*DMFS*	
	Coefficient	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*	*Coefficient*	*se*
Intercept	20.45	2.96	23.64	4.42	5.20	0.71	0.02	2.77	101.94	4.28	107.16	2.93
Gender	-4.31 ^	2.20	1.57	3.30	-1.23 *	0.53	6.03 *	2.06	-5.54	3.18	4.25 ^	2.18
Regular dental care	12.02 *	2.63	33.84 *	4.05	-1.29 *	0.63	25.55 *	2.46	-35.61 *	3.79	-11.35 *	2.60
Education-second lowest quartile	1.38	3.30	6.57	4.80	-1.06	0.79	4.79	3.08	-5.17	4.76	-1.44	3.26
Education-second highest quartile	6.08	3.80	22.72 *	5.54	-1.10	0.91	15.64 *	3.55	-20.72 *	5.49	-6.17	3.76
Education-highest quartile	10.50 *	4.08	33.98 *	5.98	-9.63	0.98	21.38 *	3.82	-31.21 *	5.89	-10.79 *	4.04
Oral behaviour middle	6.99 *	2.63	14.31 *	3.96	-0.64	0.63	9.31 *	2.46	-15.42 *	3.79	-6.75 *	2.60
Oral behaviour good	0.87	3.28	6.98	4.98	-0.63	0.79	8.52 *	3.06	-9.26 ^	4.73	-1.37	3.24
Year	-6.42	3.87	9.27	6.47	-2.14 *	0.93	2.65	3.62	-6.99	5.59	-6.49	3.83
Interact. Year/second lowest q.	7.32	5.58	3.03	8.79	1.25	1.34	2.67	5.22	-8.57	8.06	-4.65	5.52
Interact. Year/second highest q.	5.78	6.29	-12.92	9.58	3.65 *	1.51	-6.91	5.88	3.69	9.08	0.43	6.23
Interact. Year/ highest q.	9.56	6.79	-12.23	10.63	2.02	1.63	-10.29	6.35	6.83	9.81	-1.44	6.72
R2	0.16		0.36		0.06		0.43		0.39		0.17	
	^p=0.050								^p=0.051		^p=0.052	

* = p< 0.05
^ = 0.05< p< 0.07

The effect of length of education from 1983 to 2006

For this part of the analysis data files from 1983 and 2006 were combined. The interaction between length of education and study year was included in order to see if the effect of length of education was important in both years or only one of the years.

Birth-cohort 1959-60, age 23-24 and 46-47 in the combined file: Table 8 shows that the interaction between length of education and study year was not significant with the exception of the effect on sound surfaces, where those in the second lowest education group had kept nearly 15 more sound surfaces than the lowest group. Gender and regular dental care had an independent effect on mean number of sound surfaces (DS). Oral health behaviour had a significant effect on oral health variables.

Birth-cohort 1929-38, age 45-54 and 68-77 in the combined file: Table 9 shows that the effect of length of education was not dependent upon which year it was measured except that those in the second highest education quartile had more surfaces with untreated decay compared with those in the lowest quartile. In this birth-cohort gender and particularly regular dental care had an effect on several of the outcome variables. Those visiting dentists had on average, nearly 34 more functional surfaces, much higher FS and lower MS than others.

Discussion

This study has shown that the oral health environment in childhood was important for adults' oral health. Attention from parents and the local environment lead to a better oral health outcome in adulthood. Social status measured by length of education was a personal resource that guided choices leading to better oral health. The longer the education the better was the oral health. Regular dental visits were important especially for the eldest birth-cohort. Good oral health behaviours early and during adulthood were also important for oral health. Effects of more than 30 surfaces were found on indicators like missing and functional tooth surfaces. When the birth-cohorts were followed from 1983 to 2006, social status had an effect in both 1983 and 2006. Judged by the number of tooth surfaces the difference between social status groups had not increased by 2006. The latter deserves a critical comment. The cumulative DMFS measure is sensitive to increased levels of risk factors in the sense that more surfaces can be affected, until saturation is reached. When lower risk levels occur, the DMFS figures cannot decline within the same birth-cohort. The Missing, Filled and Sound indicators cannot reverse. Only the number of decayed surfaces can reverse (Holst and Schuller, 2000). In the present study the mean number of decayed surfaces was significantly reduced and indicated a falling level of risk (Holst *et al.*, 2007). With regard to estimating the influence of social status and other explanatory variables, a reduction cannot be shown, and it can only be concluded that the effect of social status did not increase from 1983 to 2006. In a cohort analysis of the relationship between social status and mean number of DMFT in 35-44- year-olds in 1983 and a new cohort of 35-44-year-olds in 2006 from the same material, the relationship between social status and number of present teeth had disappeared in 2006, and the relationship between social status and mean number of DMFT and DMFS was significantly reduced (Holst *et al.*, 2007). This shows that the DMF index can be used in cross-sectional research to comparing birth-cohorts of the same age; the index has serious limitations in longitudinal research.

It is important to draw attention to the different dimensions that the chosen oral health indicators reflect. The indicators SS and SFS reflect oral health and function and high and increasing values represent positive expressions of oral health. MF and FS are negative expressions of oral health and high and increasing values show reduced oral health. These treatment indicators have limitations since they do not include repeated treatment in the same teeth. DMFS (or DMFT) are a summarised expression of untreated and treated disease, and the values may be difficult to interpret because the indicators of the index move in different directions over time. It is important that oral epidemiology researchers engage in finding new measures of disease activity that are different from measures of treatment activity.

There are a number of threats to reliability and validity of the data when surveys are repeated and the same variables are used over time, and different birth-cohorts are exposed to the same procedures. Concepts of behavioural norms and interpretation of clinical symptoms change. The treatment criteria change (Gimmestad and Holst, 2003). Most of the questions in the present surveys, however, were about factual events and clear to the respondents; some memory bias among the respondents with regard to events at age 10 should be expected. These are measurement errors that increase the variance of the variables and reduce the discriminative ability of the statistical tests. Even though of one of the authors (DH) was present at all the surveys and has acted as the gold standard, it is difficult to avoid drift in the application of the standard criteria.

The results from the present study have a limited statistical inference with regard to the size of the population the results may be generalised to. On the other hand when it comes to modeling social processes, generalisation is based on how validly the model catches the specific underlying social processes. It was not the intention to explain all the variation in the dependent variables. It is interesting to notice that R^2 was high in the oldest cohort. It cannot be determined whether this is a cohort or an age effect. Probably it is both, assuming that age reflects the cumulative exposure to plaque during the life-course, and the later born cohorts have experienced a different environment that will result in a better oral health. There are reasons to believe that our data and the model have captured some of those social processes that were important for oral health and its development over time. Other and nationally representative Norwegian data support the finding of a more equally distributed oral health (Holst *et al.*, 2007; Holst and Skau, 2010; Skudutyte and Eriksen, 2007). The Trøndelag studies started when data on oral health and its determinants were scarce. In hindsight these studies have yielded valuable descriptions and explanations of the changes in oral health.

Norway is considered to have had a homogeneous population compared to many other countries (Krokstad and Westin, 2004). Yet, the demography, the size of the country and the arctic location have resulted in cultural and distributional differences. Living conditions and social disparities have to a large extent already affected oral health of the population in Norway (Arnljot *et al.*, 1985). During the last decade larger differences in incomes have been observed which might have led to increased social inequalities in both oral health and demand for dental services (Krokstad, 2004). That seems not to have occurred. Cross-sectional data will typically focus on cross-sectional social differences but give limited insights over time. Often the lead time between exposure and resulting effect will be ignored. Panel data and data with the present analytical potential can detect whether or not a social problem is increasing or decreasing. It cannot be ignored that the results of this study can be ascribed to welfare policies across a number of living conditions in Norway. The public dental service with a population responsibility and outreach services in this country is an example of one such public policy that has contributed to increasing public awareness of oral health. A high level of public awareness may be expected to influence both the promotion of oral health and accessible adequate dental care. A life-course perspective provides an opportunity understand oral health over time. The present study supports the assumption that oral health is continuously exposed to environmental and behavioural risks that lead to accumulated plaque in the mouth and diseases in the dental tissues.

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