Community Dent Oral Epidemiol 2008; 36: 269–278

Community Dentistry and Oral Epidemiology

Socio-economic inequality in the self-reported number of natural teeth among Norwegian adults – an analytical study

Ola Haugejorden[1], Kristin S. Klock[1], Anne N. Åstrøm[1,2], Erik Skaret[3] and Tordis A. Trovik[4]

[1]Department of Oral Sciences – Community Dentistry, [2]Centre for International Health, [3]Center of Odontophobia and [4]Centre for Clinical Dental Research, University of Bergen, Bergen, Norway

Haugejorden O, Klock KS, Åstrøm AN, Skaret E, Trovik TA. Socio-economic inequality in the self-reported number of natural teeth among Norwegian adults – an analytical study. Community Dent Oral Epidemiol 2008; 36: 269–278.

Abstract – *Objective:* To assess inequality in dental status associated with educational level, gross personal and family income among Norwegian adults. *Methods:* Data were collected by Norway's Central Bureau of Statistics in November–December 2003. A two-stage, proportional random sample comprising 2000 persons aged 16–79 years was drawn from the national population register. Information became available for 1309 subjects by interview. The present analyses pertain to 1092 subjects aged 25–79 years (response rate 66%, mean age 47.9 years). *Results:* Of the respondents, 3% were edentulous and 9% had fewer than 20 teeth. The mean number of teeth was 27.1 (SD 7.0). In multiple logistic regression analysis, low gross personal and adjusted family income were associated with increased likelihood of having fewer than 20 natural teeth (OR = 2.84, 95% CI 1.58, 5.10; OR = 3.63, 95% CI 1.99, 6.62, respectively). Educational level was significantly associated with dental status in bivariate but not in multivariate analyses, except once among males. The predictors of socio-economic inequality in dental status accounted for a limited proportion of explained variance (Nagelkerke's R^2) when controlling for age, place of residence, perceived oral health compared with others, perceived importance of oral health, dental attendance and smoking. *Conclusion:* Socio-economic inequality in dental status persists among Norwegians aged 25–79 years but absolute differences have decreased during the last 30 years. The findings are encouraging but challenging as far as choice of strategy for further reduction of differences in tooth loss.

Key words: education; income; inequality; interview; national survey; number of teeth

Ola Haugejorden, Department of Oral Sciences–Community Dentistry, Faculty of Dentistry, Aarstadveien 17, N-5009 Bergen, Norway
Tel: +47 55 58 65 94
Fax: +47 55 58 64 93
e-mail: ola.haugejorden@odont.uib.no

Submitted 9 May 2006;
accepted 14 August 2006

The indicators of socio-economic status (SES) most commonly used when studying health inequalities are educational level, income and occupation, or indices derived by combining two or all three of these indicators (1, 2). These measures of SES are supposed to reflect human, material and social capital (2). Human capital refers to the education, skills, abilities and knowledge used to obtain socially valued goods. Material capital (e.g. earned income and exchangeable property or goods) is potentially useful for acquiring good education, living conditions, health and oral health care services. Social capital may be viewed as an individual, family or household trait and can provide a mechanism through which behavioural norms are generated and maintained (2). It is assumed that the cause of inequality in health is complex and multi-factorial (1) and that the effect of SES is mediated through environmental exposure, psychosocial factors (e.g. life stress, interpersonal relationships, personality traits, major life events and absence of social support), health-related behaviour and availability of health and oral health care services (e.g. 3).

doi: 10.1111/j.1600-0528.2007.00367.x

Numerous studies have reported a social gradient in general health (e.g. 4–6), oral health (7–15), as well as in oral health-related behavioural (7, 16–22), and quality of life parameters (23). The observed differences according to SES favour the high status groups in industrialized countries. Thus in these countries, tooth loss is more prevalent among persons with a low level of education and/or income than among their counterparts with a higher level of education and/or income (7–15). Past Norwegian findings have conformed to this general pattern. National health surveys of persons 16 years of age and older in 1975, 1985 and 1995 reported that 20% (crude rate) were edentulous in 1975, had fallen to 14% in 1985 and 8% in 1995 (8–10). Groups with a low level of education, in unskilled occupations or with low income had a higher crude rate of edentulousness than their counterparts with a high level of education, in skilled occupations or with high income. The same trends have been observed in caries experience (24, 25) and in periodontal status (26).

Norway is considered a welfare state (4, 27) and successive Norwegian governments have had as their goal to reduce differences in the health status of the population (4, 5), including differences in oral health (27). The strategy to reduce socio-economic inequality in oral health has been to provide free dental care in the Public Dental Service for children, adolescents and groups of adults with special needs (28). Other measures designed to improve oral health have been preventive programmes in the Public Dental Service and dental health education campaigns through the media (29–31). Whether or not these measures have reduced socio-economic inequality in oral health, has received limited attention (25).

The purpose of the present study was to assess and compare inequality in self-reported dental status associated with educational level, gross personal and adjusted family income among Norwegian adults in 2003.

Materials and methods

The Central Bureau of Statistics (CBS) drew a two-stage, self-weighting proportional random sample ($n = 2000$, age 16–79 years) from the Norwegian national population register in September 2003 (Omnibus survey). Twenty-one persons had died or moved abroad.

The data were collected by a 30-minute telephone (98.5%) or a face-to-face (1.5%) interview performed in November–December 2003 by trained interviewers employed by the Central Bureau of Statistics. Information became available for 1309 persons, i.e. a response rate of 66.1% (1309/1979). Among nonrespondents ($n = 670$), refusals accounted for 58.5% and no contact for 20.4%. The respondents were representative of the Norwegian population aged 16–79 years with regard to age, gender and place of residence (32).

As free or subsidized dental care is available for persons 16–20 years (28) and as some people do not finish their education till about 25 years of age (4), persons 16–24 years old were excluded. This left 1102 respondents aged 25–79 years. All of them provided information about their level of education, 1092 persons provided a tooth count, 1044 answered the question about gross personal and 1001 the one about gross family income. The response rate for persons aged 25–79 years was 65.8% and their mean age 47.9 (SD = 14.5) years.

The interview covered aspects of material, human and social capital (2). Questions were asked about age, gender, marital status, level of education, gross personal and family income, the number of persons in the household, place of residence and participation in local politics. In addition, information was collected about the informants' number of natural teeth, dental attendance, perceived quality of tooth-brushing, smoking, importance of oral health and perceived oral health compared with others.

Level of education (human capital) (2) was measured in terms of the number of years of education completed. It was dichotomized as 0 = ≥ 13 years (high, i.e. college/university), 1 = < 13 years (low). The respondents' personal gross income was classed as 1 = low (<250 000 Norwegian kroner (NOK) and 0 = high (≥250 000 NOK (∼US$ 37 480)). Family (household) gross income was reported according to 10 income groups. The European Union's equivalence scale was used to adjust family income for size and composition of the household (weights: 1 person = 1, 2 = 1.5, 3 = 1.8, 4 = 2.1, etc) (4, 33). The class mid-points of gross family income were divided by the family weight factor. This adjusted gross family income variable was employed with a median split. Gross personal and adjusted family income was also split at 50% below the median (the poverty line) (34). The other demographic variables were categorized as shown in Table 1.

Table 1. Number of subjects and unadjusted odds ratio (OR) with 95% confidence interval (CI) for having fewer than 20 natural teeth – subjects aged 25–79 years, Norway 2003 (dependent variable 0 = 20–32 teeth, 1 = 0–19 teeth)

Variable	Category	*n*	OR	95% CI
Teeth	20–32	994	–	
	0–19	98	–	
Predictors of inequality				
Education	High	351	1	
	Low	740	4.60	2.36–8.97
Personal income	High	583	1	
	Low	455	4.13	2.53–6.76
Family income[a]	High	533	1	
	Low	449	4.05	2.43–6.75
Control variables				
Age (years)	25–49	626	1	
	50–79	466	11.58	6.25–21.47
Sex	Males	550	1	
	Females	542	1.11	0.73–1.68
Marital status	Other	448	1	
	Married/partner	640	1.27	0.82–1.95
Place of residence	Urban	834	1	
	Rural	258	2.33	1.52–3.60
Region	South	873	1	
	North	219	2.71	1.75–4.20
Oral hygiene	Satisfactory	910	1	
	Unsatisfactory	179	1.80	1.10–2.95
Dental visits	Regularly	742	1	
	Other	350	2.52	1.66–3.83
Smoking	No	796	1	
	Yes	296	2.29	1.50–3.50
CompOralHlth	Better	498	1	
	Equal/worse	563	3.12	1.90–5.12
Importance oral health	Important	1019	1	
	Unimportant	72	4.71	2.67–8.28
Dentist man-years	High	627	1	
	Low	465	1.66	1.10–2.52
Local politics	High	284	1	
	Low	797	1.56	0.91–2.65

[a]Adjusted for family size and composition (4, 33).

Dental attendance was assessed by the question: How many times have you seen your dentist during the last 5 years? The response alternatives were: Regularly, at least once a year, 3–4 times, 1–2 times and has not seen a dentist during the last 5 years (dichotomy: Regularly = 0, other responses = 1). Perceived quality of toothbrushing was measured by asking whether the respondents agreed or disagreed with the statement: *I do not brush my teeth well enough*. The responses were dichotomized as satisfactory (0 = strongly disagree or disagree) and unsatisfactory (1 = strongly agree, agree and neither agree nor disagree). The respondents were asked about smoking experience (yes/no) and if yes whether they smoked daily or occasionally (dichotomy: 0 = nonsmoker/occasional smoker, 1 = smoker). The responses to the statement: *I consider my dental health to be unimportant* were categorized as 0 = important (strongly disagree/disagree) and 1 = not important (strongly agree/agree/neither agree nor disagree). The question: *Compared with men/women of your own age, do you consider your dental health to be much better, a little better, a little worse or much worse*? The response alternative neither better nor worse was hidden. The responses were split as 0 = much or a little better and 1 = much worse, a little worse and neither better nor worse and the variable was labelled CompOralHlth (Comparative Oral Health).

Involvement in local community affairs was expressed as an additive index based on binary responses (0 = no, 1 = yes) to the following questions: *Did you vote in the local authority election in 2003?* and *Are you a member of a political party?* The resulting 0–2 scale was dichotomized as 0 = 0–1 (low), 1 = 2 (high).

The number of dentist man-years per 10 000 inhabitants was available for the seven regions of Norway (35), i.e. as an area measure of availability of dental services. This mean number of dentist

man-years was entered for each respondent of the region to partly control for regional variation in the availability of dental care.

Statistical analyses

The Omnibus data file was established and quality controlled by the CBS. The Statistical Package for Social Sciences (SPSS®, SPSS Inc., Chicago, IL, USA, version 13.0 for PC) was used for the analyses.

Chi-squared tests were employed to assess the significance of differences in the distribution of subjects according to the number of natural teeth and category on the predictor and control variables. The frequency distribution of subjects according to the self-reported number of natural teeth (outcome variable) exhibited significant negative skew and kurtosis. As the median did not reflect the differences in the number of teeth according to category of the predictor and control variables, some mean differences have been quoted in the text. The shape of the distribution of subjects according to the number of teeth was also the reason why bivariate and multivariate logistic regression analyses were employed to estimate odds ratios (OR) and 95% confidence intervals (CI). Odds ratios were considered statistically significant if both values of the 95% CI were either greater than or less than 1. Chi-squared tests provided the estimated fit of the logistic regression models and Nagelkerke's R^2 the strength of association between exposure and the outcome variable. The significance level was 5%.

The outcome variable (number of natural teeth), predictor and control variables were dichotomized as summarized in Tables 1 and 2. The categories were defined so that odds ratios greater than one indicate an increased likelihood of having less than 20 natural teeth. This cut-off point was chosen on clinical indications as it has been maintained that a person can manage with 20 well distributed teeth (36, 37). Based on the assumptions of Oakes & Rossi (2) and Petersen (3), a conceptual model was constructed (Fig. 1). It assumes that educational level is associated with income and beliefs and that these predictors influence dental health behaviours which in turn impact upon dental status, i.e. it incorporates aspects of human, material and social capital. The predictors and control variables were entered into the logistic regression models in five blocks as illustrated in Fig. 1 and Table 2. For predictors to be included in the final models the *P*-value had to be less than 0.10. Separate analyses were run with gross personal income and with adjusted gross family income as indicators of

Table 2. Odds ratio (OR) and 95% confidence interval (CI) for background, social status, beliefs and behavioural variables according to model for persons 25–79 years old, Norway 2003. Dependent variable: dental status (0 = 20–32; 1 = 0–19 teeth) (n = 1011)

Predictors (Categories)[a]	Model 1	Model 2	Model 3	Model 4	Model 5	Final model
Background						
Age (20–49 versus 50–79)	12.3 (6.4–23.8)	11.4 (5.9–22.0)	10.4 (5.4–20.3)	11.8 (6.0–23.3)	14.7 (7.3–29.7)	13.2 (6.6–26.1)
Marital status (married/partner versus other)	0.6 (0.4–1.0)	0.6 (0.4–1.0)	0.7 (0.4–1.2)	0.6 (0.3–1.0)	0.7 (0.4–1.2)	–
Region (south versus north)	2.9 (1.8–4.8)	2.9 (1.7–4.8)	2.8 (1.7–4.7)	2.3 (1.3–3.9)	1.9 (1.1–3.3)	1.8 (1.0–3.3)
Residence (urban versus rural)	2.3 (1.4–3.8)	2.0 (1.2–3.3)	1.9 (1.2–3.2)	1.8 (1.1–3.1)	2.1 (1.2–3.7)	2.0 (1.2–3.5)
Social status						
Education (high versus low)		2.9 (1.4–5.8)	2.0 (1.0–4.7)	2.0 (0.9–4.4)	1.6 (0.7–3.4)	1.5 (0.7–3.3)
Income[b] (high versus low)			2.4 (1.4–4.2)	2.4 (1.4–4.3)	2.7 (1.5–4.9)	2.8 (1.6–5.1)
Beliefs						
CompOralHlth (better versus equal/worse)				3.8 (2.1–6.9)	3.6 (2.0–6.5)	3.4 (1.9–6.1)
Oral hygiene (important versus unimportant)				3.8 (1.8–8.1)	2.8 (1.3–6.2)	2.7 (1.3–6.0)
Behaviour						
Dental visits (regularly versus other)					2.8 (1.6–4.8)	2.8 (1.6–4.9)
Smoking (never/occasionally versus current)					2.1 (1.2–3.6)	2.2 (1.3–3.7)
Nagelkerke's R^2	0.234	0.255	0.276	0.345	0.384	0.380
Model χ^2	110.17***	120.55***	131.23***	166.94***	187.82***	185.74***

Control variables: [a]Reference category mentioned first; [b]Gross personal income; ***$P < 0.001$.

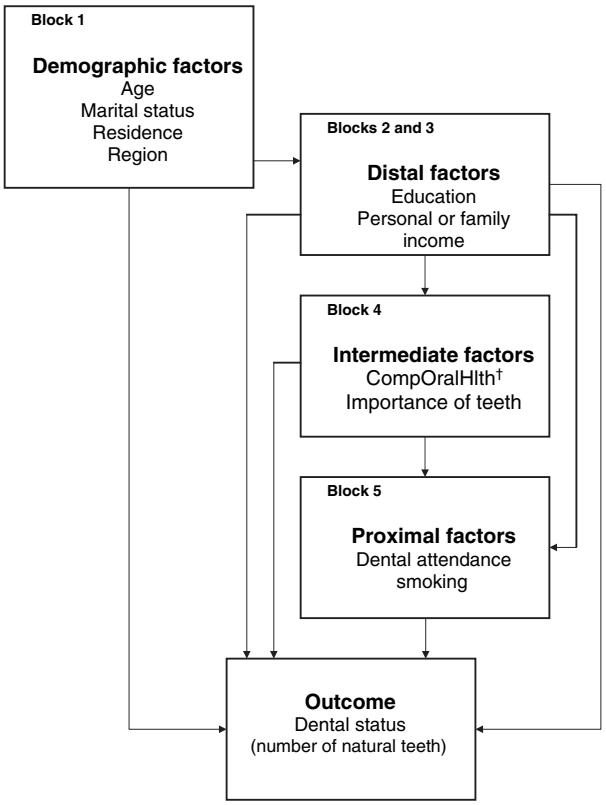

Fig. 1. Conceptual model.†CompOralHlth = Comparative Oral Health.

economic circumstances (material capital) (2). The significant association between gross personal and adjusted gross family income ($r_s = 0.68$, $P < 0.01$) was expected as 58% of households consisted of one or two persons. Otherwise there was no need for interaction terms in the multivariate logistic regression analyses ($r_s < 0.30$).

The proportion of Norwegian women in salaried employment increased from 45% in 1946 to 69% in 2003, especially among younger women (38, 39). Part-time employment is also more common among women than among men. For these reasons, it was hypothesized that gross personal and family income might impact differently on the number of natural teeth of males and females. Consequently, multiple logistic regression analyses were carried out for subjects aged 25–79 years (dichotomy 0 = 25–49, 1 = 50–79) and 40–79 years old (dichotomy 0 = 40–59, 1 = 60–79) as well as separately for males and females aged 25–79 years.

Results

Three per cent (33/1092) of the participants were edentate and 9% (98/1092) had less than 20 teeth. Their mean number of teeth was 27.1 (SD = 7.0; median 29, range 0–32) for all subjects and 28.0 (SD = 5.1, median 29, range 2–32) for dentate individuals. There was no significant difference in the number of teeth between males and females ($P = 0.694$). On the other hand, the self-reported number of natural teeth varied significantly ($P < 0.05$) according to age, place of residence (urban/rural, not males), region, level of education, gross personal and adjusted family income, oral hygiene, dental visits, smoking, perceived oral health compared with men/women of own age (CompOralHlth), perceived importance of oral health and dentist man-years (Table 1). The largest mean difference in the number of teeth between categories was for importance of oral health (5.38 teeth), followed by age (5.16 teeth), personal income (3.10 teeth), adjusted family income (2.81 teeth), level of education (2.67 teeth) and region (2.60 teeth).

In bivariate logistic regression analyses, the odds ratio for having less than 20 natural teeth was 4.60 (95% CI 2.36, 8.97) for respondents with the shortest education, 4.13 (95% CI 2.53, 6.76) when gross personal income was low and 4.05 (95% CI 2.43, 6.75) when gross adjusted family income was low (Table 1). Of the control variables, age was the most important predictor of less than 20 teeth (OR = 11.58, 95% CI 6.25, 21.47).

When controlling for gross personal income and the other significant predictors (Table 1) by multivariate logistic regression analysis, the association between education and dental status was attenuated (from OR = 4.60 to OR = 1.50) and became nonsignificant in the final model ($P = 0.313$) (Table 2, Fig. 2). The effect of gross personal income on dental status was also attenuated (from OR = 4.13 to OR = 2.84) but remained significant in the final model (Fig. 2, Table 2). When adjusted family income replaced personal income in the logistic regression model, the odds ratio for education changed from 1.50 to 1.48. Had an interaction term for gross personal and adjusted family income (multiplicative) been included in the analyses, then neither personal nor adjusted family income would have been significantly associated with dental status. Neither dentist man-years/10 000 inhabitants nor participation in local politics satisfied the criterion for inclusion in any of the final multiple logistic regression models ($P < 0.10$). Consequently, these covariates were not included in subsequent analyses.

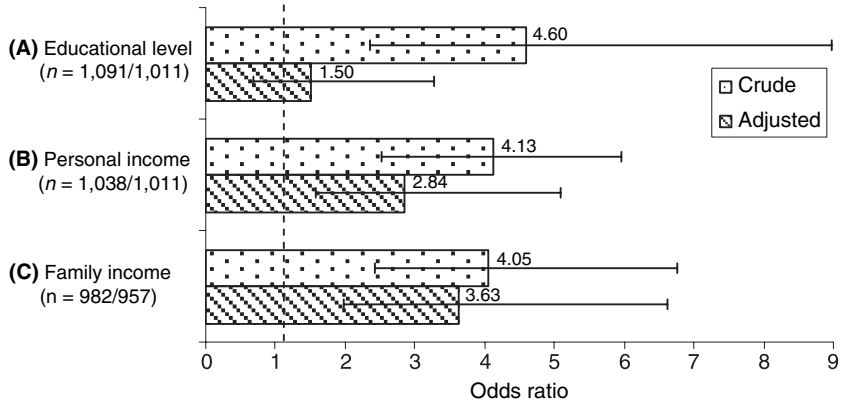

Fig. 2. Crude and adjusted odds ratio (OR) with 95% confidence interval for persons 25–79 years of age according to socio-economic predictors of oral health status disparity – Norway 2003. Dependent variable: 0 = 20–32 teeth, 1 = 0–19 teeth.

Gross personal income had a significant effect on dental status (OR = 2.84, 95% CI 1.58, 5.10) when controlling for level of education and the other significant predictors listed in Table 1. In the corresponding analyses with adjusted family income as the indicator of SES, a stronger association with the number of natural teeth was found (OR = 3.63, 95% CI 1.99, 6.62) (Fig. 2).

The odds ratio for having less than 20 teeth was 4.59 (95% CI 2.20, 9.58, $n = 514$) for gross personal income and 3.08 (95% CI 1.48, 6.37, $n = 501$) for adjusted family income among men when controlling for age, region, smoking, CompOralHlth and educational level. Among females the odds ratio increased from 2.16 (95% CI 0.73, 6.44, $n = 497$) for personal income to 4.93 (95% CI 1.51, 16.12, $n = 456$) for adjusted family income after adjusting for the effect of age, marital status, place of residence, education, importance of oral health, CompOralHlth, dental attendance and smoking. The null hypothesis stating that personal and family income are equally important predictors of dental status is accepted because the odds ratio for personal income is within the 95% CI for the odds ratio for adjusted family income.

The multivariate analyses limited to persons aged 40–79 years changed the odds ratios and their 95% confidence intervals minimally compared with the once reported for participants 25–79 years old (Tables 2 and 3).

Table 4 summarizes eight multiple logistic regression models in terms of model χ^2, Nagelkerke's R^2 and per cent correctly predicted. Per cent correctly predicted ranged from 89% to 95%, Nagelkerke's R^2 from 33.3% to 49.8%. On entering the regression models, R^2 change (%-points) for educational level was ≤3.2, for gross personal income ≤6.0, and for adjusted family income ≤7.4. This means that demographic variables other than education and income accounted for 50–60% of explained variance in the number of teeth among subjects 25–79 years old and 30–47% among persons aged 40–79 years.

The poverty line dichotomy of the income variables did not change the general pattern of association found in the multiple logistic regression analyses (Fig. 1 and Tables 1–4). The only exception

Table 3. Multiple logistic regression analyses: Odds ratio (OR) and 95% confidence interval (CI) according to gender, gross personal and adjusted family income - persons aged 40–79 years, Norway 2003. Dependent variable: 0 = 20–32, 1 = 0–19 natural teeth

	Gross personal income				Adjusted gross family income			
Description	*n*	OR	95% CI	R^2 (%)	*n*	OR	95% CI	R^2 (%)
Females[a]	327	1.98	0.64–6.07	46.9	297	8.26	2.22–30.66	50.5
Males[b]	330	4.47	2.05–9.76	33.6	321	3.04	1.42–6.48	30.6
All[c]	657	2.72	1.48–5.01	36.2	618	3.94	1.49–5.11	37.9

[a]Age, residence, marital status, education, importance of oral health, Comparative Oral Health (CompOralHlth), smoking and dental attendance.
[b]Age, region, education, CompOralHlth, dental attendance and smoking.
[c]Age, region, residence, education, importance of oral health, CompOralHlth, smoking and dental attendance.

Table 4. Summary of final multiple logistic regression models

Gross income	Subjects	Category	*n*	Model χ^2	Nagelkerke's R^2 (%)	Predicted %
Personal	All 25–79 years		1011	185.74	38.0	92.7
		Females	497	110.38	46.5	94.4
		Males	514	91.67	36.1	92.2
	All 40–79 years		657	140.28	36.2	89.2
Family[a]	All 25–79 years		957	180.04	38.7	93.0
		Females	456	108.28	49.8	95.2
		Males	501	82.97	33.3	91.6
	All 40–79 years		618	140.07	37.9	89.6

[a]Adjusted for size and composition.

was that education had a significant effect among males aged 25–79 years.

Discussion

The national self-reported rate of edentulousness was 16% among persons ≥15 years of age in Norway in 1973. The crude rate was 4.4 times higher in the lowest than in the highest income group (7). This compares with 2.5% edentate and 7.8 times (0.5% versus 3.9%) higher among persons aged 16–79 years, 3.0% and 7.9 times (0.7% versus 5.5%) among 25–79 year olds in 2003. The same trend was found in the Norwegian national health surveys in 1975, 1985 and 1995 (8–10). It should, however, be recognized that the dental status of Norwegian adults has improved regardless of income and educational level and that the percentage points difference between the extreme income groups has decreased during the last 30 years.

Only once (among males), when employing the poverty line dichotomy of income, was there a statistically significant association between level of education and the self-reported number of natural teeth after controlling for confounding by multiple logistic regression analyses. There was a significant effect of gross personal and adjusted family income, except if the interaction term between them was included in the models. As predicted, high family income tended to impact more strongly on the self-reported dental status of females (OR = 5.51) than of males (OR = 3.13) but the difference was not significant. The magnitude of this difference between odds ratios suggests further testing of the hypothesis in a study providing higher power.

The level of education was significantly associated with the number of natural teeth in bivariate analyses but only once in the final models when controlling for gross personal income in the multivariate logistic regression models. This suggests that the effect of education is mediated through other predictors of dental status (Fig. 1, Table 2) (1, 3). Educational level tended to be more important among males (one significant association) than among females but contributed less than 3.2 percentage points to explained variance in the number of natural teeth when controlling for potential confounding variables. The absence of a significant association between educational level and the number of teeth is at variance with results from Denmark (11), Sweden (12) Finland (18), the United Kingdom (13) and the United States (15) but in agreement with results from one Swedish (11) and one Finnish study (20).

The higher a person's gross personal or adjusted family income the lower the likelihood of having fewer than 20 natural teeth. This finding is in agreement with results from previous studies (7–11), but the impact of income was modest in the present investigation. The majority of the present sample will have been taught oral self-care and the importance of visiting a dentist regularly while receiving free incremental dental care from the school or the public dental services. Consequently, it may be that Norwegian adults consider dental care and retention of their natural teeth as important and assign high priority to maintaining oral health. Thus two thirds of the respondents claimed to have visited a dentist regularly, at least once a year, during the last 5 years, and 81% reported three or more visits during this period. Further support for this notion is provided by the fact that Norwegian adults find it relatively difficult to cope with the loss of teeth and getting dentures (40, 41). Another possible explanation for the comparatively modest impact of personal and family income on dental status may be that 65% of adults, who had visited a dentist during the last 12 months had paid 1500 NOK (~US$ 225) or less (42), i.e. a sum most

households can afford. Part-time work may explain why family income tended to be more important among females than among males (38, 39).

Educational level increased Nagelkerke's R^2 by less than 3.2 percentage points, personal income increased it by 6.0 percentage points and adjusted gross family income by 7.4 percentage points in the final regression models. This relatively modest impact of SES is in agreement with results of other studies in health (2). Risk behaviour in relation to diet (18, 43), smoking (18, 22, 44–46) and dental attendance (15, 47) is more likely among persons of lower than among their counterparts of higher social status. They are also more likely to receive extractions when attending for dental treatment (15, 47). This implies that the scope for reducing inequality in dental status ascribable to SES is relatively limited in the short term.

Of control variables, age was the most important predictor of the self-reported number of teeth (Table 1) (7–10, 13, 48). Place of residence and geographical region influenced the number of natural teeth in the expected direction, that is, more tooth loss in rural than in urban areas (7–10) and more in the northern than in the southern part of Norway (7–10). Smokers had lost more teeth than nonsmokers and former smokers among males, but not among females and in the whole group. An association between smoking and dental status has also been reported by others (22, 44–46). In keeping with past findings (15, 47), there was a significant association between dental attendance and the number of natural teeth. There was also a significant impact of oral hygiene, importance of oral health and CompOralHlth. In the 8 multivariate analyses, SES accounted for less than 30% of total Nagelkerke's R^2 in the self-reported number of teeth (Tables 4). Taken together the findings of this investigation are in accordance with the assumption that the effect of SES on health and dental status is indirect (Fig. 1) (1, 3).

The participants 16–79 years of age were representative of the Norwegian population according to age, gender and place of residence (32). Some subjects did not provide a tooth count. This is, however, unlikely to have biased results as the mean number of teeth was almost identical for all subjects aged 25–79 years, for those who gave their gross personal income, and for those who stated their family income. The same applied for subjects 40–79 years of age. Confounding was controlled by multiple logistic regression analyses and multicollinearity was not a problem. Consequently, it is unlikely that our findings are seriously biased by sampling error, nonresponse, confounding and multi-collinearity.

The reliability of the self-reported number of natural teeth was not assessed (49). However, many studies (50–53) have found close agreement between the clinically recorded and the self-reported number of teeth; consequently, it is unlikely that reliance on the self-reported number of natural teeth has biased the results.

The power of the multivariate analyses may have been compromised by the limited number of participants who had 0–19 natural teeth ($n = 98$ for subjects aged 25–79 years/$n = 95$ for 40–79 year olds). The cut-off point was chosen on clinical indications (36, 37). Analyses with the dependent variable defined as 0 = 25–32, 1 = 0–24 teeth, almost doubled the number of subjects in the low number of teeth category, but did not change the relationship between SES and the number of teeth markedly (results not presented). Given the nonresponse and the variability observed in this study, the number of participants would have had to be quadrupled for the effect of education to become significant at the 5% level after controlling for the other predictors in the multivariate models.

Conclusion

The dental status of Norwegian adults has improved in recent years and the absolute magnitude of the socio-economic difference has decreased. Gross personal and adjusted family income were found to be more important predictors of dental status than educational attainment but socio-economic inequality persists among persons aged 25–79 years despite Norwegian governments' intention and efforts to reduce or eliminate it. The findings are encouraging but challenging as far as choice of strategy for further reduction of inequality in dental status is concerned. More and sustained oral health promotion efforts will be needed. In addition, medically and/or economically compromised persons should either be offered treatment free of charge in the Public Dental Services or be entitled to improved insurance coverage for dental care.

Acknowledgement

The data about smoking was obtained from the Central Bureau of Statistics Norway (CBS). They were made

available in anonymous form by the Norwegian Social Science Data Services (NSD). Collection and preparation of the data were originally done by CBS. Neither CBS nor NSD is responsible for the analysis of the data and interpretations presented in this paper.
The study was financed by the Faculty of Dentistry, University of Bergen (Grant No. 101330).

References

1. Braveman P, Gruskin S. Defining equity in health. J Epidemiol Community Health 2003;57:254–8.
2. Oakes JM, Rossi PH. The measurement of SES in health research: current practice and steps toward a new approach. Soc Sci Med 2003;56:769–84.
3. Petersen PE. Social inequality in dental health. Towards a theoretical explanation. Community Dent Oral Epidemiol 1990;18:153–8.
4. Kunst AE, Bos V, Lahelma E, Bartley M, Lissau I, Rigidor E et al. Trends in socioeconomic inequalities in self-assessed health in 10 European countries. Int J Epidemiol 2005;34:295–305.
5. Dahl E, Kjærsgaard P. Trends in socioeconomic mortality differentials in post-war Norway: evidence and interpretations. Sociol Health Illn 1993;15:587–611.
6. Næss Ø, Claussen B, Smith GD. Relative impact of childhood and adulthood socioeconomic conditions on case specific mortality in men. J Epidemiol Community Health 2004;58:597–8.
7. Heløe LA, Holst D, Rise J. Development of dental status and treatment behavior among Norwegian adults 1973–85. Community Dent Oral Epidemiol 1988;16:52–7.
8. Central Bureau of Statistics. Health Survey 1975. Oslo: Central Bureau of Statistics; 1977. p. 52–7.
9. Central Bureau of Statistics. Health Survey 1985. Oslo: Central Bureau of Statistics; 1987.
10. Central Bureau of Statistics. Health Survey 1995. Statistical yearbook 1997. Oslo: Central Bureau of Statistics; 1997.
11. Palmqvist S, Söderfeldt B, Vigild M, Kihl J. Dental conditions in middle-aged and older people in Denmark and Sweden: a comparative study of the influence of socioeconomic and attitudinal factors. Acta Odontol Scand 2000;58:113–8.
12. Unell L, Söderfeldt B, Halling A, Birkhed D. Explanatory models for oral health expressed as number of remaining teeth in an adult population. Community Dent Health 1998;15:155–61.
13. Treasure E, Kelly M, Nuttall N, Nunn J, Bradnock G, White D. Factors associated with oral health: a multivariate analysis of results from the 1998 Adult Dental Health survey. Br Dent J 2001;190: 60–8.
14. Krustrup U, Petersen PE. Voksenundersøgelsen i Danmark 2000/2001. Carieserfaring og parodontal status hos voksne i relation til social status og udnyttelse af tandplejen. Tandlægebladet 2005;109: 798–812.
15. Gilbert GH, Duncan RP, Shelton BJ. Social determinants of tooth loss. Health Serv Res 2003;38:1843–62.
16. Krall EA, Dawson-Hughes B, Garvey AJ, Garcia RI. Smoking, smoking cessation, and tooth loss. J Dent Res 1997;76:1653–9.
17. Tomar SL, Azevedo AB, Lawson R. Adult dental visits in California: successes and challenges. J Public Health Dent 1998;58:275–80.
18. Åstrøm AN, Rise J. Socio-economic differences in patterns of health and oral health behaviour in 25 year old Norwegians. Clin Oral Invest 2001;5:122–8.
19. Pearce MS, Steele JG, Mason J, Walls AWG, Parker L. Do circumstances in early life contribute to tooth retention in middle age? J Dent Res 2004;83:562–6.
20. Ylostalo P, Sakki T, Laitinen J, Jarvelin MR, Knuuttila M. The relation of tobacco smoking to tooth loss among young adults. Eur J Oral Sci 2004;112:121–6.
21. Ståhlnacke K, Söderfeldt B, Unell L, Halling A, Axtelius B. Changes over 5 years in utilization of dental care by a Swedish age cohort. Community Dent Oral Epidemiol 2005;33:64–73.
22. Susin C, Oppermann RV, Haugejorden O, Albandar JM. Tooth loss and associated risk indicators in an adult urban population from Brazil. Acta Odontol Scand 2005;63:85–93.
23. Åström AN, Haugejorden O, Skaret E, Trovik TA, Klock KS. Oral Impacts on Daily Performances (OIDP) in Norwegian adults: the influence of age, number of missing teeth and socio-demographic factors. Eur J Oral Sci 2006;114:115–21.
24. Berset GP, Eriksen HM, Bjertness E, Hansen BF. Caries experience of 35-year-old Oslo residents and changes over a 20-year period. Community Dent Health 1996;13:238–44.
25. Schuller AA. Better oral health, more inequality – empirical analysis among young adults. Community Dent Health 1999;16:154–9.
26. Hansen BF, Bjertness E, Gjermo P. Changes in periodontal disease indicators in 35-year-old Oslo citizens from 1973 to 1984. J Clin Periodontol 1990;17:249–54.
27. Norges offentlige utredninger NOU 2005: 11. Det offentlige engasjement på tannhelsefeltet. Et godt tilbud til de som trenger det mest. Oslo: Statens forvaltningstjeneste; 2005.
28. Sosialdepartementet. Dental Health Service Act. Oslo: Sosialdepartementet; 1983.
29. Birkeland JM, Haugejorden O, Fehr FR vd. Analyses of the caries decline and incidence among Norwegian adolescents 1985–2000. Acta Odontol Scand 2002;60:281–9.
30. Rise J, Søgaard AJ. Effect of a mass media periodontal campaign upon preventive knowledge and behavior in Norway. Community Dent Oral Epidemiol 1988;16:1–4.
31. Søgaard AJ. Effect of a nationwide periodontal health campaign on dentists' awareness, attitude and behavior in Norway. Community Dent Oral Epidemiol 1988;16:30–5.
32. Normann TM. Omnibusundersøkelsen november–desember 2003. Dokumentasjonsrapport. Oslo: Statistisk sentralbyrå; 2004. p. 8–12.
33. Central Bureau of Statistics. Økonomi og levekår for ulike grupper, 2004. Oslo: Central Bureau of Statistics; 2004. (http://www.ssb.no/emner/05/01/rapp_200428/rapp_200428.pdf).

34. Bojer H. Hva er fattigdom? (What is poverty?). Oslo: Aftenposten; 2005. p. 4.
35. Central Bureau of Statistics. Avtalte årsverk i tannhelsetjenesten 2003. Oslo: Central Bureau of Statistics; 2004 (http://www.ssb.no/emner/03/02/tannhelse/).
36. Käyser AF. Minimum number of teeth needed to satisfy functional and social demands. In: Frandsen A, editor. Public health aspects of periodontal disease. Chicago: Quintessence Publishing Co, Inc; 1984. p. 135–47.
37. Elias AC, Sheiham A. The relationship between satisfaction with mouth and number and position of teeth. J Oral Rehabil 1998;25:649–61.
38. Statistisk sentralbyrå. Historisk statistikk 1994 (Historical Statistics 1994). Oslo: Statistisk sentralbyrå; 1995. p. 227–52.
39. Statistisk sentralbyrå. Statistisk årbok 2004. Oslo: Statistisk sentralbyrå; 2004. p. 211.
40. Haugejorden O, Rise J, Klock KS. Norwegian adults' perceived need for coping skills to adjust to dental and non-dental life events. Community Dent Oral Epidemiol 1993;21:57–61.
41. Klock KS, Haugejorden O. Measurement and predictors of young adults' perceived ability to cope with life events. Acta Odontol Scand 2002;60:129–35.
42. Holst D, Grytten J, Skau I. Den voksne befolknings bruk av tannhelsetjenester i Norge i 2004. Nor Tannlegeforen Tid 2005;115:212–6 (English summary: Demand for dental services and expenditures for dental treatment in the Norwegian adult population).
43. James WPT, Nelson M, Ralph A, Leather S. Socioeconomic determinants of health: The contribution of nutrition to inequalities in health. BMJ 1997;314:1545–9.
44. Gelskey SC. Cigarette smoking and periodontitis: methodology to assess the strength of evidence in support of a causal association. Community Dent Oral Epidemiol 1999;27:16–24.
45. Albandar JM. Global risk factors and risk indicators for periodontal diseases. Periodontol 2000 2002;29:177–206.
46. Klein BE, Klein R, Knudtson MD. Life-style correlates of tooth loss in an adult Midwestern population. J Public Health Dent 2004;64:145–50.
47. Sheiham A, Maizels J, Cushing A, Holmes J. Dental attendance and dental status. Community Dent Oral Epidemiol 1985;13:304–9.
48. Marcus SE, Drury TF, Brown LJ, Zion GR. Tooth retention and tooth loss in the permanent dentition of adults: United States, 1988–1991. J Dent Res 1996;75(Spec Iss):684–95.
49. Åström AN, Haugejorden O, Skaret E, Trovik TA, Klock KS. Oral Impacts on Daily Performance (OIDP) in Norwegian adults: validity, reliability and prevalence estimates. Eur J Oral Sci 2005;113:289–96.
50. Heløe LA. Comparison of dental health data obtained from questionnaires, interviews and clinical examination. Scand J Dent Res 1972;80:495–9.
51. Axelsson G, Helgadottir S. Comparison of oral health data from self-administered questionnaire and clinical examination. Community Dent Oral Epidemiol 1995;23:365–8.
52. Unell L, Söderfeldt B, Halling A, Paulander J, Birkhed D. Oral diseases, impairment, and illness: congruence between clinical and questionnaire findings. Acta Odontol Scand 1997;55:127–32.
53. Gilbert GH, Chaves LS, Shelton BJ. Comparison of two methods of estimating 48-month tooth loss incidence. J Public Health Dent 2002;62:163–9.