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Education level and oral health in Finnish adults: evidence from different lifecourse models

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Abstract

Aim: To assess the relationship between education level and several oral health outcomes in Finnish adults, using three conceptual lifecourse models.

Materials and Methods: This study analysed data from 7112 subjects, aged 30 years or over, who participated in the nationally representative Finnish Health 2000 Survey. Parental and own education levels were the childhood and adulthood socioeconomic measures, respectively. Oral health was indicated by edentulousness, perceived oral health and levels of dental caries and periodontal disease. Three conceptual lifecourse models, namely critical period, accumulation and social trajectories, were separately tested in regression models.

Results: In line with the critical period model, parental and own education levels were independently associated with oral health after mutual adjustment. There was also a graded linear relationship between the number of periods of socioeconomic disadvantage and oral health, corresponding to the accumulation model. Gradual declines in oral health were evident between social trajectories from persistently high to upwardly mobile, downwardly mobile and persistently low groups.

Conclusion: There was similar support for the lifecourse models of critical period, accumulation and social trajectories. They collectively contribute to a better understanding of oral health inequalities.

Key words: dental caries; lifecourse; periodontal disease; socioeconomic position; teeth

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The relationship between socioeconomic position (SEP) and adult oral health has been extensively investigated (Watt & Sheiham 1999, Locker 2000, Poulton et al. 2002, Thomson et al. 2004, Sanders et al. 2006, Sabbah et al. 2007). However, evidence on socioeconomic inequalities in adult oral health is mostly limited to adult SEP despite the fact that adverse socioeconomic circumstances may influence oral health at critical or different stages in life and/or have accumulative effects over time. To better understand how SEP influences oral health, it is more useful to conceptualise SEP across the lifecourse (Nicolau et al. 2007b).

A lifecourse approach to chronic disease epidemiology recognises how socially patterned exposures across the lifespan influence adult disease risk and SEP, and hence may account for social inequalities in adult morbidity and mortality (Kuh & Ben-Shlomo 2004, Lynch & Davey Smith 2005, Blane et al. 2007). Three conceptual models have been used to clarify the highly complex and dynamic lifecourse processes: the *critical period model* maintains that an exposure at a specific period in the lifespan results in permanent and irreversible damage or disease; the *accumulation model* considers that risks to health accumulate gradually over the lifecourse, and thus, focuses on the total amount of exposure; and the *social trajectories model* is a special case of the accumulation model and refers to chains of risk by which one negative exposure increases the subsequent risk of another negative exposure (Ben-Shlomo & Kuh 2002, Kuh et al. 2003, Kuh &

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests.
The Health 2000 Survey (http://www.terveys2000.fi/indexe.html) was organised by the National Institute for Health and Welfare (THL), formerly the National Public Health Institute (KTL), of Finland, and partly supported by the Finnish Dental Society Apollonia and the Finnish Dental Association. Eduardo Bernabé was supported by the Programme Alβan, the European Union Programme of High Level Scholarships for Latin America, Scholarship No. E06D1000352PE. Mika Kivimäki is supported by the Academy of Finland (projects 117604, 1244271 and 124332).

Ben-Shlomo 2004). These models are not mutually exclusive and may operate simultaneously (Kuh & Ben-Shlomo 2004, Lynch & Davey Smith 2005, Blane et al. 2007).

The few lifecourse studies on SEP and adult oral health have tended to focus on the critical period model, providing mixed results. Using data from ongoing birth cohorts, the Dunedin Multidisciplinary Health and Development Study in New Zealand found that parental occupation was related to tooth cleanliness, gingival bleeding, periodontal disease and dental caries at age 26 years, after controlling for current adult occupation (Poulton et al. 2002), whereas the Newcastle Thousand Families Study in the United Kingdom found that parental social class was not related to tooth retention at age 50 years after controlling for contemporaneous social class (Pearce et al. 2004). A cross-sectional study among Brazilian middle-aged women found that parental education was related to periodontal disease independent of own education (Nicolau et al. 2007a). On the other hand, both the Dunedin Longitudinal Study Health and Development Study (Poulton et al. 2002, Thomson et al. 2004) and Newcastle Thousand Families Study (Pearce et al. 2009) provided only partial support for social trajectories affecting adult oral health in terms of the social origins, upward mobility and downward mobility hypotheses. Interpretation of the abovementioned lifecourse studies is complicated by methodological differences between studies, including different SEP measures and oral health outcomes.

In Finland, adult oral health has considerably improved in the last decades. However, edentulousness remains a serious issue among older generations and dental caries and especially periodontal diseases are still major oral health problems, particularly in men and older women. Furthermore, there are marked socioeconomic inequalities in adult oral health, with a particularly strong association between oral health and education level (Aromaa & Koskinen 2004, Koskinen et al. 2006, Suominen-Taipale et al. 2008). Income-related health inequalities in Finland are relatively small compared with other countries due to the more universal welfare coverage that reduce income inequalities (Gottschlak & Schmeeding 1997, van Doorslaer et al. 1997, Laaksonen et al. 2009).

This study examined the relationship between education level and several oral health outcomes, using different conceptual lifecourse models, in a nationally representative sample of Finnish adults.

Materials and Methods

Study population

The Health 2000 Survey was a multidisciplinary study aimed at providing a comprehensive picture of the health and functional ability in the Finnish population aged 30 years and over by studying the prevalence and determinants of most important health problems, including oral health, and associated need for care, rehabilitation and help. The survey was carried out between September 2000 and June 2001 by the National Institute for Health Welfare (THL, former the National Public Health Institute of Finland). The two-stage stratified cluster sample was representative of the Finnish national population and included 8028 subjects aged 30 years or over. Subjects were interviewed at home (phase 1), where they were also given a questionnaire to be returned at the clinical health examination (phase 2). A total of 7419 subjects (93% of the 7977 subjects alive on the first day of phase 1) attended at least one phase of the study and 6335 subjects (79%) had clinical oral health examinations (Aromaa & Koskinen 2004, Suominen-Taipale et al. 2008).

Socioeconomic measures and lifecourse models

Parental and own education levels were the childhood and adulthood socioeconomic measures, respectively. Education level of both parents when participants started school (i.e. around the age of 7 years) was ascertained and the higher one was selected to indicate parental education. Parental education was then divided into three groups: low (primary school or less), middle (secondary school or vocational training) and high education (matriculation or a university degree). For the purpose of this study, middle and high education groups were combined into a single category. Subject's level of education was indicated by a three-class variable. No vocational training beyond a vocational course or on-the-job training with no matriculation examination was classified as basic education. Completion of vocational school as well as passing the matriculation examination but having no vocational training beyond a vocational course or on-the-job training was defined as secondary education. Higher education comprised degrees from higher vocational institutions, polytechnics and universities. For this study, secondary and higher education groups were combined into a single category.

Three lifecourse models were tested: critical period, accumulation and social trajectories (Ben-Shlomo & Kuh 2002, Kuh & Ben-Shlomo 2004, Lynch & Davey Smith 2005, Blane et al. 2007). The critical period model was assessed through the association between parental education and oral health outcomes, independently of own education. For testing the accumulation model, a summary score was created by summing up the number of periods in the low education group over the lifecourse. This score varied from 0 to 2, with 0 indicating no exposure to socioeconomic disadvantage during the lifespan (reference group), 1 indicating exposure to socioeconomic disadvantage either in childhood or adulthood and 2 indicating exposure to socioeconomic disadvantage in both childhood and adulthood. Finally, social trajectories were tested by inter-generational social mobility. Four possible trajectories were evaluated based on parental and own education with an underlying hierarchy: persistently high (reference group), upwardly mobile, downwardly mobile and persistently low groups (Hallqvist et al. 2004, Singh-Manoux et al. 2004, Pollitt et al. 2005, Rosvall et al. 2006).

Oral health outcomes

Four oral health outcomes were evaluated: edentulousness and perceived oral health were assessed among all subjects, whereas dental caries and periodontal disease were assessed among dentate subjects only. These outcomes are the most commonly used oral health measures in epidemiological surveys; they collectively cover both clinical and perceived outcomes and reflect different aspects of oral health, function and disease.

Subjects reported their perceived oral health status on a five-point scale, which was later dichotomised for analysis as poor (poor/rather poor/moderate) or good (rather good/good). Clinical oral examinations were conducted according

to World Health Organization guidelines (WHO 1997). Five dentists carried out the clinical examinations with the subject seated on a dental chair and using a headlamp, mouth mirror, fibre optic light and a WHO periodontal probe. Subjects were considered as edentate if they had not teeth at all or as dentate if they had at least one natural tooth. Dental caries was diagnosed for each tooth surface but recorded by tooth. A tooth was recorded as decayed if there was evidence of a caries lesion clearly extending into dentine on any coronal or root surface. The caries lesion had to be cavitated, to have penetrated the fissure and undermined the enamel, or the dentine walls to be clearly softened. The number of decayed teeth per subject was calculated if the condition of all his/her teeth had been clinically determined. Periodontal pocket depth was measured on four sites of each tooth, excluding the wisdom teeth. All teeth with pocket depths of 4 mm or more at any site were recorded as teeth with periodontal pockets. The percentage agreement in the parallel measurements on 269 subjects, where field examiners were individually compared with the reference examiner under field circumstances, was 93% (κ 0.87) for dental status by tooth and 77% (κ 0.41) for periodontal pockets by tooth (Suominen-Taipale et al. 2008). κ values for intra-examiner reliability on 111 subjects were 0.95 for dental status by tooth and 0.83 for periodontal pockets by tooth (Suominen-Taipale et al. 2004).

Statistical analysis

All analyses were conducted using STATA software, which allowed taking into account analysis weights to correct for the effect of non-response, and the complex survey design to adjust standard errors and confidence intervals accordingly. Subjects with missing data for either the outcome or any explanatory variable were excluded from that particular analysis (pairwise deletion).

Appropriate regression models were chosen for each outcome based on its measurement scale and distribution. Log-binomial regression was preferred over logistic regression for edentulousness and perceived oral health as both outcomes were dichotomous and relatively common (prevalence $>10\%$). Prevalence ratios were therefore reported. On the other hand, negative binomial regression was used for the number of decayed teeth and the number of teeth with periodontal pockets, as they were count variables with overdispersion. For the latter two outcomes, the number of teeth (in its continuous form) was used as the offset variable in regression models. Rate ratios were reported.

For the critical period model, the associations of parental and own education with each outcome were assessed in three sequential steps: unadjusted, age- and sex-adjusted and mutually adjusted models. For the accumulation model, the association between the accumulated number of periods in the low education group and each outcome was assessed in unadjusted and age- and sex-adjusted models. Linear trends were assessed fitting the accumulated number of periods as a continuous variable. For the social trajectories model, the association between four different trajectories and each outcome was assessed in unadjusted and age- and sex-adjusted models. Linear trends were assessed fitting the different trajectories as a continuous variable. Furthermore, the regression estimates for the downwardly and upwardly mobile groups were compared using the Wald test.

Owing to the wide age range of the sample, the moderating role of age in the relationship between education level and each outcome was examined by testing the significance of the interaction of age (in its continuous form) with parental and own education for the critical period model, with accumulated number of periods in the low education group for the accumulation model and with trajectories for the social trajectories model, in regression models also including the main effects.

Results

Data from 7112 adults (3343 men and 3769 women) were analysed. Their mean age was 53 years (range 30–99 years). Thirteen per cent of the subjects were edentate and 35% reported poor perceived oral health. Among the 5401 dentate subjects, the mean number of decayed teeth was 0.8 and the mean number of teeth with periodontal pockets of 4 mm or more was 4.2 (Table 1).

Table 2 shows findings on the critical period model. In the age- and sex-adjusted models, parental and own education levels were related to the four oral health outcomes. The associations of parental education with each oral health outcome were attenuated but remained significant in the mutually adjusted models, except for number of teeth with periodontal pockets. By contrast, own education was related to each oral health outcome independent of parental education. In all models, own education was more strongly related to each oral health outcome than parental education.

Findings on the accumulation model are shown in Table 3. There were significant linear trends in the four oral health outcomes by accumulated number of periods in the low education group ($p<0.001$ for all cases). The prevalence of edentulousness and poor-perceived oral health significantly increased at each higher level of risk accumulation (from zero to two periods in the low education group). Similarly, there were higher numbers of decayed teeth and teeth with periodontal pockets as the level of cumulative exposure to low socioeconomic disadvantage increased.

Table 4 shows findings on the social trajectories model. Significant trends in

Table 1. Characteristics of the sample of the Finnish Health 2000 Survey

Characteristics	All ($n=7112$)	Dentate ($n=5401$)
Sex (%)		
Men	48	49
Women	52	51
Mean age in years (SE)	53.0 (0.2)	49.6 (0.2)
Parental education (%)		
High	34	37
Low	66	63
[Missing data]*	[531]	[251]
Own education (%)		
High	59	67
Low	41	33
[Missing data]*	[40]	[22]
Edentulousness (%)		
Dentate	87	
Edentate	13	
[Missing data]*	[796]	
Perceived oral health (%)		
Good	65	
Poor	35	
[Missing data]*	[94]	
Mean number of decayed teeth (SE)		0.8 (0.03)
[Missing data]*		[12]
Mean number of teeth with periodontal pockets 4 mm or more (SE)		4.2 (0.1)
[Missing data]*		[146]

*Bases are unweighted.

Table 2. Regression models for the association of parental and own education with oral health outcomes (critical period model)

Education level	N*	Outcome distribution		Model 1A†	Model 1B†	Model 1C†
		n*	% or mean (95% CI)	estimate (95% CI)	estimate (95% CI)	estimate (95% CI)
Edentulousness‡						
Parental education						
High	2031	108	5% (4–6%)	1.00	1.00	1.00
Low	3951	726	17% (16–18%)	3.41 (2.81–4.14)	1.90 (1.58–2.30)	1.42 (1.17–1.72)
Own education						
High	3682	165	4% (4–5%)	1.00	1.00	1.00
Low	2300	669	27% (25–29%)	6.40 (5.42–7.56)	2.73 (2.31–3.22)	2.50 (2.09–2.99)
Poor perceived oral health‡						
Parental education						
High	2171	629	29% (27–31%)	1.00	1.00	1.00
Low	4354	1671	38% (36–40%)	1.31 (1.21–1.42)	1.20 (1.12–1.30)	1.12 (1.04–1.22)
Own education						
High	3897	1143	29% (28–31%)	1.00	1.00	1.00
Low	2628	1157	44% (42–46%)	1.48 (1.39–1.59)	1.34 (1.24–1.44)	1.30 (1.19–1.41)
Number of decayed teeth§						
Parental education						
High	1920	–	0.65 (0.56–0.73)	1.00	1.00	1.00
Low	3218	–	0.90 (0.82–0.98)	1.84 (1.57–2.15)	1.46 (1.25–1.71)	1.29 (1.11–1.50)
Own education						
High	3512	–	0.67 (0.60–0.74)	1.00	1.00	1.00
Low	1626	–	1.09 (0.98–1.20)	2.57 (2.23–2.96)	1.97 (1.68–2.29)	1.86 (1.60–2.18)
Number of teeth with periodontal pockets 4 mm or more§						
Parental education						
High	1891	–	4.07 (3.77–4.37)	1.00	1.00	1.00
Low	3121	–	4.22 (3.89–4.54)	1.21 (1.12–1.31)	1.09 (1.02–1.17)	1.05 (0.98–1.12)
Own education						
High	3453	–	4.03 (3.75–4.31)	1.00	1.00	1.00
Low	1559	–	4.45 (4.03–4.86)	1.44 (1.33–1.57)	1.20 (1.10–1.31)	1.19 (1.09–1.30)

*Bases are unweighted.
†Model 1A was unadjusted, Model 1B adjusted for sex and age (continuous) and Model 1C further adjusted for the other education measure.
‡Log-binomial regression was fitted and prevalence ratios reported.
§Negative binomial regression was fitted and rate ratios reported.

Table 3. Regression models for the association between accumulated number of periods in the low education group and oral health outcomes (accumulation model)

Number of periods in low education group	N*	Outcome distribution		Model 2A†	Model 2B†
		n*	% or mean (95% CI)	estimate (95% CI)	estimate (95% CI)
Edentulousness‡					
0 (high–high)	1705	41	2% (2–3%)	1.00	1.00
1 (low–high, high–low)	2303	191	8% (7–9%)	3.25 (2.32–4.57)	2.41 (1.72–3.36)
2 (low–low)	1974	602	28% (26–30%)	12.08 (8.82–16.56)	4.37 (3.21–5.96)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]
Poor perceived oral health‡					
0 (high–high)	1802	475	27% (24–29%)	1.00	1.00
1 (low–high, high–low)	2464	822	33% (31–35%)	1.25 (1.13–1.38)	1.21 (1.09–1.33)
2 (low–low)	2259	1003	44% (42–46%)	1.66 (1.51–1.82)	1.47 (1.33–1.62)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]
Number of decayed teeth§					
0 (high–high)	1663	–	0.57 (0.48–0.65)	1.00	1.00
1 (low–high, high–low)	2106	–	0.81 (0.72–0.91)	1.76 (1.46–2.13)	1.53 (1.27–1.84)
2 (low–low)	1369	–	1.08 (0.96–1.19)	3.38 (2.79–4.09)	2.37 (1.92–2.92)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]
Number of teeth with periodontal pockets 4 mm or more§					
0 (high–high)	1637	–	4.02 (3.71–4.33)	1.00	1.00
1 (low–high, high–low)	2068	–	4.09 (3.76–4.41)	1.12 (1.03–1.21)	1.07 (0.99–1.15)
2 (low–low)	1298	–	4.46 (4.00–4.92)	1.54 (1.39–1.70)	1.24 (1.12–1.37)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]

*Bases are unweighted.
†Model 2A was unadjusted and Model 2B adjusted for sex and age (continuous).
‡Log-binomial regression was fitted and prevalence ratios reported.
§Negative binomial regression was fitted and rate ratios reported.

Table 4. Regression models for the association between different social trajectories and oral health outcomes (social trajectories model)

Trajectories	N^*	Outcome distribution		Model 3A†	Model 3B†
		n^*	% or mean (95% CI)	estimate (95% CI)	estimate (95% CI)
Edentulousness‡					
High–high	1705	41	2% (2–3%)	1.00	1.00
Low–high	1977	124	6% (5–7%)	2.48 (1.73–3.57)	2.02 (1.41–2.88)
High–low	326	67	19% (15–23%)	7.99 (5.55–11.51)	3.92 (2.76–5.56)
Low–low	1974	602	28% (26–30%)	12.08 (8.82–16.56)	4.45 (3.26–6.06)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]
Poor perceived oral health‡					
High–high	1802	475	27% (24–29%)	1.00	1.00
Low–high	2095	668	32% (30–34%)	1.2 (1.08–1.33)	1.17 (1.06–1.30)
High–low	369	154	41% (36–46%)	1.55 (1.33–1.80)	1.42 (1.22–1.65)
Low–low	2259	1003	44% (42–46%)	1.66 (1.51–1.82)	1.48 (1.34–1.63)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]
Number of decayed teeth§					
High–high	1663	–	0.57 (0.48–0.65)	1.00	1.00
Low–high	1849	–	0.76 (0.67–0.86)	1.58 (1.32–1.91)	1.41 (1.17–1.68)
High–low	257	–	1.17 (0.86–1.48)	3.10 (2.23–4.31)	2.49 (1.79–3.47)
Low–low	1369	–	1.08 (0.96–1.19)	3.38 (2.79–4.09)	2.39 (1.94–2.94)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]
Number of teeth with periodontal pockets 4 mm or more§					
High–high	1639	–	4.02 (3.71–4.33)	1.00	1.00
Low–high	1814	–	4.05 (3.71–4.39)	1.09 (1.00–1.18)	1.05 (0.97–1.13)
High–low	252	–	4.37 (3.69–5.06)	1.36 (1.16–1.59)	1.19 (1.01–1.40)
Low–low	1307	–	4.46 (4.00–4.92)	1.54 (1.39–1.70)	1.24 (1.12–1.37)
[Test for linear trend]				[$p<0.001$]	[$p<0.001$]

*Bases are unweighted.
†Model 3A was unadjusted and Model 3B adjusted for sex and age (continuous).
‡Log-binomial regression was fitted and prevalence ratios reported.
§Negative binomial regression was fitted and rate ratios reported.

the oral health outcomes were found by social trajectories ($p<0.001$ for all cases) in the following order (from better to worse oral health): persistently high, upwardly mobile, downwardly mobile and persistently low groups. Furthermore, there were significant differences between the upwardly and downwardly mobile groups in the prevalence of edentulousness ($p<0.001$) and poor perceived oral health ($p=0.008$) as well as in the number of decayed teeth ($p<0.001$). However, there was no difference between the upwardly and downwardly mobile groups with respect to the number of teeth with periodontal pockets ($p=0.121$).

Age modified the association of education level with edentulousness and number of teeth with periodontal pockets, but not with perceived oral health and number of decayed teeth, in all three lifecourse models. In the critical period model, the adjusted associations of parental and own education with edentulousness and number of teeth with periodontal pockets of 4 mm or more are weakened by an increasing age. Likewise, the adjusted associations of accumulated number of periods in the low education group and social trajectories with edentulousness and number of teeth with periodontal pockets were, respectively, attenuated when age increased (Table 5).

Discussion

We retrospectively explored different lifecourse models for the association between education level and various aspects of oral health in a nationally representative sample of Finnish adults. Overall, our findings provide similar support for all three different conceptual lifecourse models of critical period, accumulation and social trajectories. This finding was in agreement with previous studies on other health outcomes (Hallqvist et al. 2004, Singh-Manoux et al. 2004, Pollitt et al. 2005, Rosvall et al. 2006) and indicates that the three models are not mutually exclusive and may operate simultaneously (Kuh & Ben-Shlomo 2004, Lynch & Davey Smith 2005, Blane et al. 2007).

First, there was evidence for an independent contribution of parental education to adult oral health (critical period model). However, own education was more strongly related to each oral health outcome than parental education. This finding is consistent with many (Poulton et al. 2002, Nicolau et al. 2007a), but not all (Pearce et al. 2004) previous studies. Most importantly, both parental and own education levels were associated with oral health outcomes. The lack of association between parental education and periodontal disease, which is in contrast to some previous reports (Poulton et al. 2002, Nicolau et al. 2007a), may be explained by differences in study population, the socioeconomic measure used or the type of periodontal outcome assessed.

Second, our results showed a clear graded relationship between accumulation of socioeconomic exposure and oral health, which supports the accumulation model. That is, increasing levels of socioeconomic disadvantage over time were associated with an increasingly greater prevalence of edentulousness and poor perceived oral health as well as progressively higher levels of dental caries and periodontal disease. Although there is no comparable oral health research, the results of this study are consistent with previous lifecourse epidemiological studies on cardiovascular

Table 5. Estimates of the association between education level and oral health outcomes using three lifecourse models in Finnish adults with different ages

Lifecourse model	Young age* estimate† (95% CI)	Middle age* estimate† (95% CI)	Old age* estimate† (95% CI)
Edentulousness‡			
Critical period model			
High parental education	1.00	1.00	1.00
Low parental education	2.93 (1.99–4.30)	2.04 (1.56–2.67)	1.42 (1.18–1.72)
High own education	1.00	1.00	1.00
Low own education	6.58 (4.82–9.00)	3.97 (3.17–4.96)	2.39 (2.02–2.83)
Accumulation model			
0 (high–high)	1.00	1.00	1.00
1 (low–high or high—low)	2.36 (1.33–4.17)	2.29 (1.51–3.47)	2.22 (1.59–3.11)
2 (low–low)	12.41 (7.38–20.89)	7.2 (4.94–10.48)	4.17 (3.10–5.62)
Social trajectories model			
High–high	1.00	1.00	1.00
Low–high	1.99 (1.09–3.65)	1.96 (1.26–3.05)	1.92 (1.34–2.75)
High–low	5.28 (2.58–10.82)	4.23 (2.56–6.98)	3.38 (2.36–4.85)
Low–low	12.41 (7.38–20.89)	7.20 (4.94–10.48)	4.17 (3.10–5.62)
Number of teeth with periodontal pockets 4 mm or more§			
Critical period model			
High parental education	1.00	1.00	1.00
Low parental education	1.53 (1.29–1.81)	1.25 (1.13–1.39)	1.02 (0.95–1.10)
High own education	1.00	1.00	1.00
Low own education	2.39 (1.86–3.07)	1.75 (1.49–2.06)	1.28 (1.17–1.40)
Accumulation model			
0 (high–high)	1.00	1.00	1.00
1 (low–high or high–low)	1.35 (1.11–1.64)	1.17 (1.04–1.31)	1.02 (0.94–1.09)
2 (low–low)	2.88 (2.20–3.78)	1.95 (1.64–2.32)	1.32 (1.19–1.47)
Social trajectories model			
High–high	1.00	1.00	1.00
Low–high	1.29 (1.05–1.57)	1.14 (1.01–1.28)	1.00 (0.93–1.08)
High–low	2.18 (1.36–3.48)	1.59 (1.18–2.15)	1.17 (0.99–1.38)
Low–low	2.89 (2.20–3.79)	1.95 (1.64–2.32)	1.32 (1.19–1.47)

*Young and old age were calculated as 1 SD below and above the mean-centred age (middle age).
†Adjusted for sex, age, own education and the interaction of age with own education for the critical period model (or vice versa when reporting estimates for own education). Adjusted for sex, age and the interaction of age with accumulated period in the low education group for the accumulation model. Adjusted for sex, age and the interaction of age with trajectories for the social trajectories model.
‡Log-binomial regression was fitted and prevalence ratios reported.
§Negative binomial regression was fitted and rate ratios reported.

disease and mortality (Pollitt et al. 2005, Turrell et al. 2007, Loucks et al. 2009).

Third, there was a gradual deterioration of the oral health status by social trajectories such that progressively worse oral conditions were found, in that order, among persistently high, upwardly mobile, downwardly mobile and persistently low groups. The main distinction between the accumulation and social trajectories models was that the latter highlighted more the extent to which changes in education level were associated with different outcomes in adulthood. The social trajectories model distinguished between upward and downward mobility in subjects with identical accumulated period of socioeconomic disadvantage. In line with other studies (Poulton et al. 2002, Thomson et al. 2004), the differences between the upwardly and downwardly mobile groups were significant in most cases, supporting the social trajectories model and the notion of distinguishing between these groups. In addition, we found worse oral conditions in the downwardly mobile group compared with the upwardly mobile group emphasizing the importance of proximal experiences of low education level in adult oral health. This finding, along with that observed on the critical period model, suggests that oral health in adult life may be more influenced by current rather than past socioeconomic conditions (Pearce et al. 2004).

Although the focus of this study is not the underlying mechanisms through which SEP affects adult oral health, it is important to speculate on these mechanisms. There is evidence to suggest that the association between childhood SEP and adult health probably comes about through a variety of processes including, but not limited to cognitive and emotional development, educational progress, the acquisition of social competences and psychological response strategies, the adoption of health-related behaviours and the development of child's health and biological resources (van de Mheen et al. 1998, Galobardes et al. 2004, Graham & Power 2004, Kuh & Ben-Shlomo 2004, Galobardes et al. 2006a). Important determinants of oral health, such as behavioural and psychosocial factors, may develop during childhood and track into adulthood (Pearce et al. 2004, Thomson et al. 2004, Sanders & Spencer 2005, Nicolau et al. 2007a, Sanders et al. 2007). Relatively stable patterns of hygiene behaviours and dietary practices are established early in life (Lynch et al. 1997, van de Mheen et al. 1998). Furthermore, childhood SEP influences nutritional development and immune system maturation, which may alter immune function and lead to an increased susceptibility to infectious or inflammatory oral diseases later in life (Sheiham & Nicolau 2005, Nicolau et al. 2007b).

Some limitations of this study are that we used data from a survey conducted 10 years ago. A comprehensive reform of the education system was conducted in the 1970s to increase the level of formal education throughout the Finnish population and provide more equal, universal educational opportunities (Laaksonen et al. 2005, Laaksonen et al. 2009). Therefore, we do acknowledge that this may have potentially affected the educational classifications in the population. However, as the oldest cohorts educated under the new system are currently younger than 40 years, findings from the Health 2000 Survey are still relevant today. Second, we used retrospective data on parental education, which could be subject to memory bias, potentially greater measurement error and underestimation of associations (Galobardes et al. 2004, Kauhanen et al. 2006). The fact that early life socioeconomic circumstances are more poorly indexed in comparison with measures in adulthood may explain why mutual adjustment tended to favour adulthood measures (Galobardes et al. 2004, Galobardes et al. 2006a). However, some studies have demonstrated that childhood SEP could be accurately recalled in adulthood, especially when using temporal references (Berney &

Blane 1997, Krieger et al. 1998). The Health 2000 Survey included four questions on parental education linked to a specific memorable event (when participants started school) to facilitate recollection. A third limitation was the focus on education-based measures only. We chose education as our SEP measure because it is fairly stable after accomplished and relevant to people regardless of age or working circumstances, unlike other SEP measures. Besides, education is a strong determinant of the individual's future employment and income. Within the lifecourse framework, education measures the transition from childhood SEP to one that will be the individual's own (Krieger et al. 1997, Galobardes et al. 2006b). In addition, we assessed only two specific time points in the lifecourse. This is the simplest scenario in lifecourse epidemiology and therefore unlikely to represent the entire array of socioeconomic circumstances that individuals experience across the lifespan. Therefore, our findings need to be corroborated in further studies using alternative measures of both childhood and adulthood SEP measured in more points over the lifespan. A fourth limitation is that inter-examiner agreement for periodontal pockets was only moderate overall and lower than for tooth condition, which implies that the former variable was more prone to measurement bias. This is not a unique characteristic of this survey, but rather a standard feature across epidemiological surveys, reflecting the difficulty to examine and precisely measure pocket depth under field circumstances. As levels of pocket depth are probably under-recorded, the estimates of the association between education level and the number of teeth with periodontal pockets in the three lifecourse models may be somewhat conservative. Finally, we should not assume, without testing it, that the lifecourse models apply equally well to all age groups and different oral health outcomes. In this sample, the associations between education level and oral health outcomes in the three lifecourse models were fairly consistent across ages; however, the associations for edentulousness and number of teeth with periodontal pockets 4 mm or more were somewhat weaker in older generations. Future studies could benefit from exploring the same set of associations across different age groups and/or cohorts.

In conclusion, experiences of socioeconomic disadvantage during childhood and adulthood (as indicated by parental and own education, respectively) were related to various clinical and subjective aspects of oral health. The three lifecourse models of critical period, accumulation and social trajectories appear to collectively contribute to an understanding of oral health inequalities.

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Clinical Relevance

Scientific rationale for the study: Evidence on lifecourse socioeconomic influences on adult oral health is limited and inconclusive. The relative importance of the three lifecourse models in relation to oral health has not heretofore been evaluated.

Principal findings: Findings supported all three lifecourse models: namely critical period, accumulation and social trajectories: (1) parental and own education levels were independently related to oral health; (2) cumulative socioeconomic disadvantage over time was associated with decreasing levels of oral health; and (3) there was a gradual deterioration of oral health status by social trajectories.

Practical implications: The conceptual lifecourse models of critical period, accumulation and social trajectories can improve current understanding of socioeconomic inequalities in oral health.