Community Dent Oral Epidemiol 2006; 34: 184–96

Community Dentistry and Oral Epidemiology

Social gradients in periodontal diseases among adolescents

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López R, Fernández O, Baelum V. Social gradients in periodontal diseases among adolescents. Community Dent Oral Epidemiol 2006; 34: 184–96.

Abstract – *Objective:* To investigate the association between socioeconomic position and periodontal diseases among adolescents. *Methods:* Data were obtained from 9203 Chilean high school students. Clinical examinations included direct recordings of clinical attachment level and the necrotizing ulcerative gingival lesions. Students answered a questionnaire on various dimensions of socioeconomic position. Seven periodontal outcomes were analyzed. Logistic regression analyses were used to identify socioeconomic variables associated with the periodontal outcomes. *Results:* The occurrence of all periodontal outcomes investigated followed social gradients, and paternal income and parental education were the most influential variables. *Conclusions:* The study demonstrates the existence of significant social gradients in periodontal diseases already among adolescents. This is worrying, and indicates a new potential for further insight into the mechanisms of periodontal disease causation.

Key words: adolescence; epidemiology; necrotizing ulcerative gingivitis; periodontal attachment loss, periodontitis; socioeconomic factors

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Submitted 22 February 2005; accepted 1 September 2005

The current periodontal paradigm holds that adolescents may be affected by several 'clinically distinct periodontal infections' (1). These are thought to include chronic and aggressive periodontitis, and necrotizing periodontal diseases, and their prevalence among adolescents is generally considered to be quite low (1). Most of the research into the etiology of these allegedly distinct disease entities focuses on aspects of the complex biological interplay between the infecting plaque microorganisms and the immunological and genetic factors involved in the host response (1). The view adopted is that of the classical biomedical paradigm, i.e. the search for the downstream, biological causes of rare conditions (2).

An intriguing but well-documented finding for adolescent periodontitis is that 'cases' are more frequent among ethnic minority populations than among their majority population counterparts (3–14). While the causes of these contrasts have most often remained unexplained (3, 5–8, 10, 11, 14), it has been suggested that they originate in microbiologic, immunologic or genetic factors related to ethnic background (9, 13, 15). Others, albeit usually in passing, have attributed them to socioeconomic factors (4, 12). This is noteworthy because similar contrasts observed in adult populations, where periodontitis is a much more common condition, have been attributed to a complex mix of upstream social, cultural, and behavioral factors related to socioeconomic position and sociocultural environment (16–20). Only a few studies exist in which the effect of socioeconomic position on the prevalence of adolescent periodontitis has been addressed in its own right (8, 21), and the results suggest that lower socioeconomic position may indeed be associated with 'case' status.

The purpose of the present study was to investigate the effects of socioeconomic position on the periodontal conditions found in a large group of randomly selected adolescents, the periodontal conditions of whom have previously been described (22–25). In addition, the study explores the extent to which the classification system used to define periodontitis cases has bearings on the possible socioeconomic gradients.

Material and methods

The data used for this analysis originate in a cross-sectional study of clinical attachment loss and necrotizing ulcerative gingival lesions among high school students from the Province of Santiago, Chile (22, 23). The local Committee of Ethics of the University of Chile, Santiago, approved the study protocol. The target population was defined as all students attending the four grades covering adolescence (13–19 years) in the high schools of the Province of Santiago. We performed a two-stage random-cluster sampling procedure involving the selection of 310 classes from 98 high schools (22).

First-stage sampling

Using information on governmental support and the full list of high schools from the Province provided by the Ministry of Education of Chile, we generated a list of high schools receiving partial or total support from the government ($n = 333$) and another containing those high schools which do not receive public funds ($n = 285$) (22). Each list was arranged in a random sequence using the procedure 'random.exe' of the statistical package PEPI (26). Both lists were then merged to obtain a single random permutation of high schools in such a way that publicly funded schools alternated with privately funded schools. The headmasters of the first 133 high schools of the list were contacted to obtain information on the number of students in the last four grades and the number of classes. A total of 104 schools were found to be eligible and were invited to participate in the study. Six headmasters declined to participate, leaving 98 schools that were included in the study (22).

Second-stage sampling

The size of the schools varied considerably and a second sampling stage was designed. For small schools where the number of students in the last four grades was ≤100, or where the number of classes was ≤3, all classes were included in the study. In larger schools, where the number of students in the last four grades was >100 and the number of classes was >3, the procedure 'random.exe' of PEPI (26) was used to select three classes for inclusion (22). Each class received a unique identification number.

A total of 9203 students aged 12–21 years present in the selected classes were invited to participate and accepted to fill a brief questionnaire on oral health-related behaviors and conditions (22). Only 40 students refused to participate in the clinical examination, and 9163 students were therefore clinically examined. Four trained and calibrated examiners conducted the clinical examination, which comprised direct measurement of clinical attachment level (CAL) measured (in millimeters) at six sites (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual/mesio-palatal, mid-lingual/mid-palatal, and disto-lingual/disto-palatal) of each of the incisors and first and second molars (22), as well as the recording of signs of necrotizing ulcerative gingivitis (NUG). CAL was defined as the distance from the cemento-enamel junction to the base of the clinical pocket. NUG was diagnosed when at least one interproximal papilla presented with necrotic ulcerated lesions, which had a punched-out appearance and loss of surface tissue. No attempts were made to record the presence of bleeding or pain. All papillae in the mouth were examined but no attempts were made to count the number of affected papillae (23). In one student, who presented with trismus, it was not possible to record the clinical attachment levels.

The intraexaminer agreement for clinical attachment loss recordings ranged between 96.5% and 98.8%, while the corresponding interexaminer agreement ranged between 94.6% and 96.0% (27). No attempts were made to assess the reliability of the NUG recordings. The reasons were twofold, as the expected low prevalence would result in an extremely high number of students being needed for repeat examinations (23), just as the 'invasive nature' of CAL recordings could compromise the value of repeat NUG recordings (23).

All students who underwent the clinical examination also filled an additional questionnaire concerning their socioeconomic position. The information sought included: household size (number of subjects living in the same residence); type of housing (owned and paid; owned paying; rented; living with others; borrowed residence); number of cars owned by the family (none; one car; two cars; three or more cars); size of the paternal, maternal and other sources of family monthly income in thousands of Chilean pesos (no income; income <$100; income $100–$299; income $300–$499; income $500–$999; income ≥$1000); and the level of paternal and maternal education attained (no education; incomplete primary school; primary school completed; incomplete high school; high school completed; incomplete technical education; technical education completed; incomplete university education; university education completed).

Household size was used to account for the number of subjects supported by the family income (28, 29) and as a proxy variable for residential crowding (30). The number of cars owned and housing status were used as indicators of wealth (29). We included information on parental monthly income and parental attained education because only sparse individual information on income and education is available from adolescents and because previous data have shown that those parental-based social indicators have implications for adolescent health status (31) and adolescents' unhealthy behavior (32).

Analyses

Seven periodontal outcomes were considered: presence of NUG; of at least one site with CAL ≥1 mm; of at least one site with CAL ≥3 mm; as well as of case status according to four different definitions of adolescent periodontitis [C1 = localized periodontosis according to Baer (33); C2 = localized juvenile periodontitis according to Genco et al. (34); C3 = localized juvenile periodontitis according to Löe and Brown (11); and C4 = localized early-onset periodontitis according to Albandar et al. (35)]. Univariable logistic regression analyses were carried out for the eight social variables investigated, and variables showing a P-value < 0.25 in the univariable analyses were selected to be included as covariates in age- and gender-adjusted multivariable logistic regression analyses. The option 'robust cluster' for the procedure 'logit' in Stata version 9.0 (36) was used to take account of the fact that the students were nested in classes (ultimate sampling unit) that were nested in schools (primary sampling unit). Hence, the variable 'class' had 310 unique values that expressed the combination of school and class within the school. The models were built by the consecutive exclusion of one variable from each full model using the likelihood ratio test as described by Hosmer and Lemeshow (37), and refitting and verifying the stability of the model after each deletion to build the best-fitting and most parsimonious model. Once the final model was built, the variables that had been excluded after the univariable analysis were added back into the model, one at a time, and the logistic regression analyses repeated to identify variables that might have made a contribution to the model in the presence of other variables (37).

Obviously, if the social variables are indeed associated with the periodontal disease outcome variables considered here, it is reasonable to anticipate that they do not exert a direct influence on oral health, but operate through intermediate steps in the causal pathway from socioeconomic position to periodontal disease. In order to identify possible intermediary steps in the pathway from socioeconomic position to periodontal conditions, we calculated the odds ratios for the association between the socioeconomic variables that were included in the final regression models and three behavioral variables (tooth brushing frequency; time since last visit to dentist; and cumulative number of packs of cigarettes smoked).

In order to explore the vulnerability of our results to the effects of misclassification of NUG status, we carried out a series of simulations based on the assumption that classification errors were unsystematic, i.e. the total number of NUG cases identified would remain at 618. We simulated three situations, whereby 10% (approximately 62 subjects), 20% (approximately 124 subjects), or 30% (approximately 186 subjects) of the NUG cases were considered false-positive (misclassified) cases, and the same number of noncases were considered false-negative. For each of the three situations, we performed 100 simulations using random sampling procedures [procedure 'sample' of Stata version 9.0 (36)] to identify the misclassified subjects. The logistic regression analysis was repeated for each of the new dataset thus generated, and the mean β coefficients for the covariates 'size of household', 'number of cars owned', 'income-father', and 'education-father' were calculated and compared with the estimates obtained in the logistic regression analysis of the original data.

Results

The response rates for the different indicators of socioeconomic position ranged from 82.8% for the variable 'other sources of family income' to 99.2% for the variable 'type of housing' (Table 1). For each periodontal outcome investigated, the prevalence estimates varied considerably according to the different categories of each socioeconomic position variable. Subjects in the categories representing the lowest socioeconomic position presented the highest prevalence estimates (Table 1). Overall, the distribution of the prevalence estimates for all the different periodontal outcomes followed social gradients so that the estimates for subjects in each

Table 1. Distribution of periodontal conditions according to the demographic and socioeconomic characteristics of the study population ($n = 9163$)

Determinant (distribution in population)	Prevalence of:[a] NUG	CAL ≥1	CAL ≥3	C1	C2	C3	C4
Overall % in population (100%)	6.7	69.2	4.5	3.0	3.5	1.3	0.5
Age (years)							
12–14 (22.5%)	6.2	65.7	3.0	2.1	2.4	0.8	0.5
15–17 (69.5%)	6.7	69.5	4.5	3.0	3.6	1.4	0.5
18–21 (8.0%)	8.3	77.0	8.2	5.6	6.3	2.3	1.1
Gender							
Boys (50.8%)	6.6	69.0	4.0	2.6	3.1	1.1	0.4
Girls (49.2%)	6.9	69.5	4.9	3.4	3.9	1.5	0.6
Size of household							
1–3 persons (14.6%)	6.2	68.7	3.6	2.5	2.8	1.0	0.4
4–6 persons (68.2%)	6.1	68.3	4.4	3.1	3.5	1.3	0.5
7 or more persons (15.7%)	9.6	73.2	5.4	3.2	4.2	1.7	0.6
Not answered (1.5%)	10.4	74.1	5.2	3.0	3.7	1.5	0.7
Type of housing[b]							
Owned, paid (47.6%)	6.5	68.6	4.2	2.9	3.3	1.2	0.4
Owned, paying (26.8%)	6.4	69.1	4.6	3.2	3.6	1.3	0.6
Rented (15.9%)	6.6	68.2	4.3	2.9	3.3	1.2	0.7
Other (8.9%)	9.1	74.7	5.8	3.5	4.7	1.6	0.5
Not answered (0.8%)	8.1	70.3	2.7	2.7	2.7	2.7	0
Number of cars owned							
2 or more cars (21.2%)	4.6	64.5	2.4	1.4	1.6	0.9	0.4
1 car (35.0%)	6.2	68.2	3.9	2.6	3.1	1.0	0.3
No car (39.0%)	8.5	72.6	6.1	4.3	5.0	1.8	0.7
Not answered (4.8%)	6.4	70.3	4.1	2.7	3.0	1.4	0.9
Income – father[c]							
≥$500 000 (24.7%)	4.1	63.3	2.3	1.3	1.5	0.6	0.1
$300–$499 000 (14.4%)	6.1	69.2	3.0	1.9	2.4	1.1	0.5
$100–$299 000 (33.7%)	7.7	70.0	5.5	3.6	4.5	1.5	0.6
<$100 000 (12.4%)	10.1	75.8	7.1	5.5	6.0	2.3	1.2
No income (6.3%)	6.3	73.6	4.7	3.0	3.5	1.9	0.7
Not answered (8.6%)	7.3	70.7	5.4	3.8	3.8	1.1	0.4
Income – mother[c]							
≥$500 000 (8.1%)	3.9	64.5	1.7	0.8	1.2	0.5	0.3
$300–$499 000 (8.5%)	5.4	66.9	3.1	2.2	2.2	1.0	0.5
$100–$299 000 (21.7%)	5.8	69.4	4.1	2.8	3.4	1.3	0.5
<$100 000 (17.1%)	9.0	72.8	6.3	4.5	5.2	1.9	0.7
No income (40.6%)	7.2	69.2	4.9	3.1	3.8	1.3	0.5
Not answered (4.0%)	6.4	67.1	2.8	2.5	2.5	1.1	0.3
Income – other sources[c]							
≥$500 000 (2.4%)	4.6	68.2	2.3	1.4	1.4	0.9	0.5
$300–$499 000 (3.4%)	5.5	69.5	4.2	2.3	2.9	1.0	0.3
$100–$299 000 (14.0%)	8.2	70.2	4.4	3.0	3.7	1.2	0.5
<$100 000 (12.4%)	8.1	72.5	5.3	3.9	4.7	1.9	0.7
No income (50.6%)	6.3	68.2	4.2	2.7	3.1	1.1	0.4
Not answered (17.2%)	6.4	69.1	5.1	3.8	4.1	1.5	0.7
Education – father[d]							
Technical/university completed (30.5%)	4.3	64.2	2.8	1.8	2.0	0.9	0.3
High school completed (32.3%)	6.4	67.3	3.4	2.4	2.7	0.9	0.3
Up to primary school completed (32.5%)	9.2	74.9	7.0	4.7	5.7	2.2	1.1
Not answered (4.8%)	7.7	75.6	4.7	3.2	3.6	0.9	0
Education – mother[d]							
Technical/university completed (26.7%)	4.4	65.0	3.0	1.8	2.2	0.6	0.1
High school completed (34.2%)	6.0	67.4	3.1	2.2	2.5	1.1	0.4

category were related to the position of the category in the social hierarchy of each variable (Table 1).

The multivariable logistic regression analyses showed that students living in a family with seven or more members (OR = 1.49, 95% CI = 1.1–2.0),

Table 1. (Continued)

Determinant (distribution in population)	Prevalence of:[a] NUG	CAL ≥1	CAL ≥3	C1	C2	C3	C4
Up to primary school completed (37.8%)	9.0	73.7	6.8	4.6	5.4	2.1	1.0
Not answered (1.4%)	8.1	74.2	1.6	1.6	1.6	0	0

$ = Chilean pesos.
[a]See text for definitions of outcomes.
[b]Categories 'living with others' and 'borrowed residence' were collapsed into 'other'.
[c]Categories '$500 000–999 000' and '≥$1 000 000' were collapsed into ≥$500 000.
[d]Categories 'no education'; 'incomplete primary school'; 'primary school completed', and 'incomplete high school' were collapsed into 'up to primary school completed'. The categories 'high school completed', 'technical incomplete', and 'university incomplete' were collapsed into 'high school completed'; the categories 'technical education completed' and 'university education completed' were collapsed into 'technical/university completed'.

students with a father whose income was lower than $100 000 (OR = 1.57, 95% CI = 1.1–2.2) and students whose father had achieved only up to primary school education (OR = 1.64, 95% CI = 1.3–2.1) were more likely to present with NUG (Table 2). Similarly, students reporting to live in a family without a car, with a father whose income is lower than $100 000, and whose attained level of education is no more than primary school education were overrepresented among students with CAL ≥1 mm and CAL ≥3 mm, respectively (Table 1). Overall, being a case according to any of the four periodontitis classification systems used to define case status was positively associated with living in a family with no car, with a paternal income <$100 000, and having parents who achieved only primary school education (Table 2).

The odds ratios for an association between the behavioral variables 'tooth brushing frequency', and 'time since last visit to dentist' and the socioeconomic position variables indicated that these variables are associated. Moreover, the odds ratios illustrated that subjects in relatively lower socioeconomic positions are consistently more likely to brush their teeth less often than those in the immediately adjacent upper socioeconomic position category, just as they are more likely to visit a dentist only rarely or never (Figs 1 and 2).

The odds ratios for the association between the variable 'cumulative number of packs smoked' and the socioeconomic position variables did not follow a clearly identifiable pattern (Fig. 3).

Table 3 shows that the effect of misclassification of NUG, as expected, was to bias estimates toward the null hypothesis of no association. However, the results of the simulations illustrate the robustness of our findings of a social gradient in the occurrence of NUG. Hence, the association between NUG presence and the various indicators of socioeconomic position remained positive even when 30% misclassification was assumed.

Discussion

It is a well-established fact that the socioeconomic position of individuals, groups, and places are defining characteristics for the levels of systemic health and disease (38–43). The effect of socioeconomic position on the occurrence and severity of ill health is not restricted to individuals and groups characterized by absolute deprivation or poverty, but shows at every level of the social hierarchy, generating what is known as the 'social gradient in health' (38, 43–46). The results of the present study demonstrated that periodontal diseases among adolescents are no exception to this rule. The higher frequency of periodontal diseases is not limited to subjects at the bottom of the social hierarchy, but manifests itself as a gradient at every level of the social hierarchy. We thus observed a direct relationship between the relative socioeconomic position of the subjects and the occurrence of periodontal diseases, no matter how the periodontal outcomes were defined. This observation demonstrates that social inequalities in periodontal health are discernible along the entire spectrum of socioeconomic positions. A similar observation was made by Locker (47) who emphasized that masking of the effect of area-based measures of deprivation on oral health outcomes may occur when deprivation categories are collapsed into only a few. As the health determinants associated with low socioeconomic position are not likely to be the same as those accounting for oral health differences in the higher socioeconomic strata, it is

Table 2. The final multivariable logistic regression models describing socio-economic indicators as determinants of each of the seven periodontal conditions

	Disease outcomes[a]						
Determinants	NUG	CAL ≥1	CAL ≥3	C1	C2	C3	C4
Size of household							
1–3 persons	1	–	–	–	–	–	–
4–6 persons	1.01 [0.8–1.3]	–	–	–	–	–	–
7 or more persons	1.49 [1.1–2.0]	–	–	–	–	–	–
Not answered	1.70 [0.9–3.1]	–	–	–	–	–	–
Type of housing							
Owned, paid	–	1	–	–	–	–	–
Owned, paying	–	1.04 [0.9–1.2]	–	–	–	–	–
Rented	–	1.01 [0.9–1.2]	–	–	–	–	–
Other	–	1.23 [1.0–1.5]	–	–	–	–	–
Not answered	–	1.06 [0.6–1.8]	–	–	–	–	–
Number of cars owned							
2 or more cars (ref)	1	–	1	1	1	–	1
1 car (1)	1.23 [0.9–1.6]	–	1.40 [1.0–2.0]	1.55 [1.0–2.4]	1.59 [1.0–2.4]	–	0.60 [0.2–1.5]
No car (2)	1.40 [1.0–1.8]	–	1.58 [1.1–2.3]	1.82 [1.2–2.9]	1.82 [1.2–2.8]	–	0.90 [0.4– 2.1]
Not answered (3)	1.12 [0.7–1.8]	–	1.23 [0.7–2.2]	1.36 [0.7–2.8]	1.24 [0.6–2.4]	–	1.39 [0.4–4.8]
Income – father							
≥$500 000 (24.7%)	1	1	1	1	1	1	–
$300–$499 000 (14.4%)	1.24 [0.9–1.7]	1.24 [1.1–1.4]	1.09 [0.7–1.7]	1.14 [0.7–2.0]	1.21 [0.7–2.0]	1.76 [0.8–3.8]	–
$100–$299 000 (33.7%)	1.32 [1.0–1.8]	1.15 [1.0–1.3]	1.55 [1.1–2.3]	1.74 [1.1–2.8]	1.82 [1.2–2.8]	1.78 [0.9–3.6]	–
<$100 000 (12.4%)	1.57 [1.1–2.2]	1.42 [1.2–1.7]	1.68 [1.1–2.6]	2.29 [1.4–3.9]	2.07 [1.3–3.4]	2.34 [0.1–5.1]	–
No income (6.3%)	1.0 [0.6–1.5]	1.30 [1.0–1.6]	1.21 [0.7–2.1]	1.32 [0.7–2.5]	1.30 [0.7–2.4]	2.28 [0.9–5.5]	–
Not answered (8.6%)	1.29 [0.9–1.9]	1.12 [0.9–1.4]	1.71 [1.0–2.8]	1.97 [1.1–3.4]	1.71 [1.0–3.0]	1.79 [0.7–4.6]	–
Education – father							
Techn. or univ. completed	1	1	1	–	1	1	1
High school completed	1.27 [1.0–1.6]	1.07 [1.0–1.2]	0.96 [0.7–1.3]	–	0.96 [0.7–1.4]	0.59 [0.3–1.1]	0.77[0.3–2.2]
Up to primary completed	1.64 [1.3–2.1]	1.46 [1.3–1.7]	1.49 [1.0–2.2]	–	1.77 [1.2–2.5]	1.00 [0.5–1.9]	1.81 [0.6–5.1]
Not answered	1.44 [0.9–2.3]	1.63 [1.3–2.1]	1.11 [0.6–2.0]	–	1.19 [0.6–2.3]	0.61 [0.2–2.0]	nd
Education – mother							
Techn. or univ. completed	–	–	1	1	–	1	1
High school completed	–	–	0.83 [0.6–1.2]	0.99 [0.7–1.5]	–	1.83 [0.9–3.6]	2.98 [0.8–11.3]
Up to primary completed	–	–	1.23 [0.9–1.7]	1.59 [1.1–2.3]	–	2.59 [1.3–5.3]	4.69 [1.2–18.9]
Not answered	–	–	0.40 [0.1–1.7]	0.70 [0.2–3.0]	–	nd	nd

[a]See text for definitions of outcomes.
–, Variable not influential.
nd, not determined due to no cases.
Values given are odds ratios [95% confidence interval].

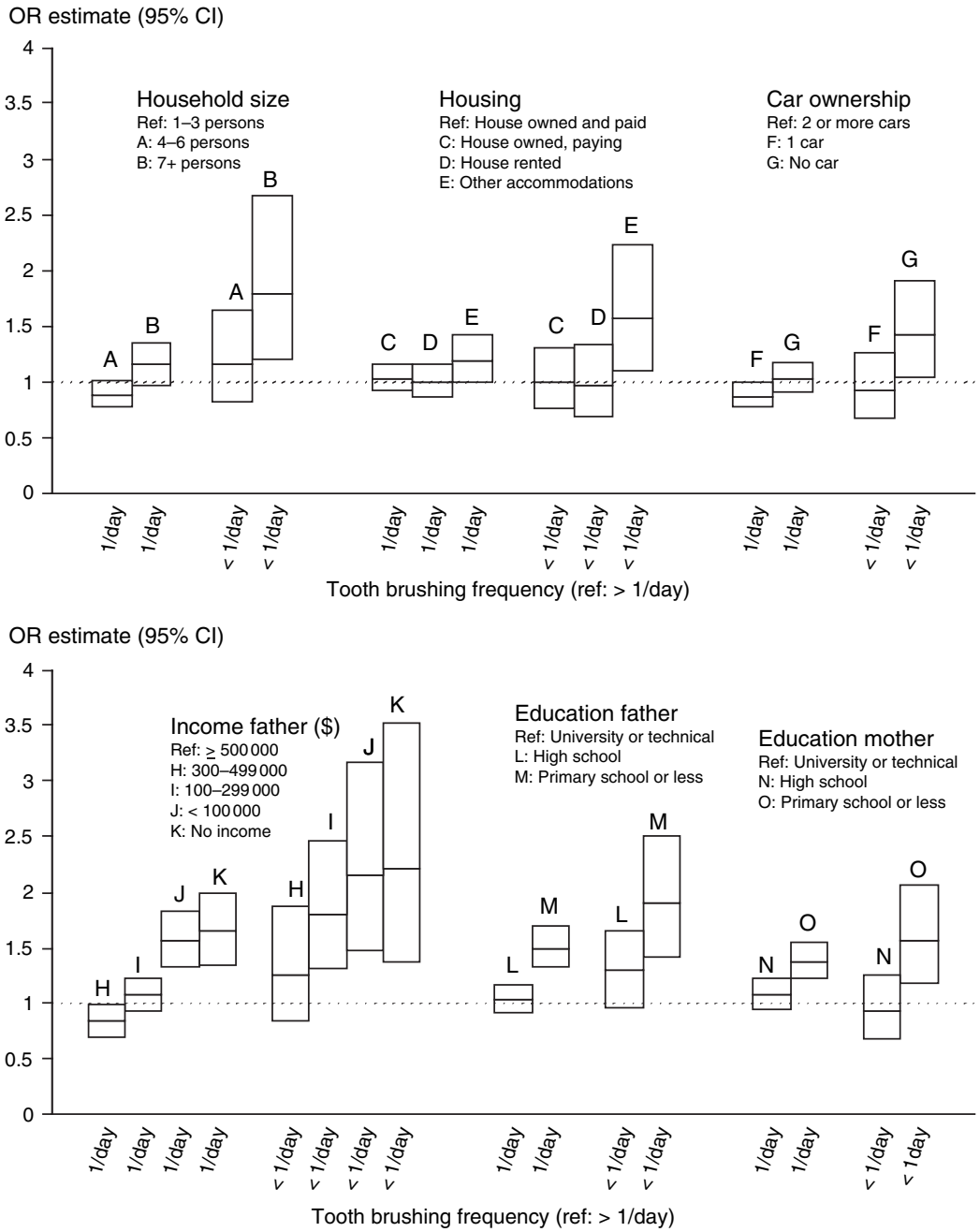

Fig. 1. Odds ratios for the association between the social variables included in the final logistic regression models and the variable tooth brushing frequency (95% confidence intervals included).

of paramount importance to acknowledge the existence of this social gradient (44). Doing so may reveal hitherto ignored mechanisms and causal chains leading to the development of periodontal diseases.

The justification for the use of several periodontal outcomes in the present study originated from our concern that the field of periodontal diagnosis remains rather confused (48–50). Many periodontitis classifications have been in vogue over the last decades (24) but most have turned out to be rather short-lived. The issue of periodontitis among children and young adults began with the periodontosis classification proposed by Baer (33), crossed juvenile periodontitis (11, 34), and early-onset periodontitis (35), before the idea of particular attention to age was abandoned with the current widely adopted classification which distinguishes between aggressive and chronic forms of periodontitis (51, 52). Despite the fundamental change of concept represented by the latter classification, it is frequently observed in the literature that epidemiological

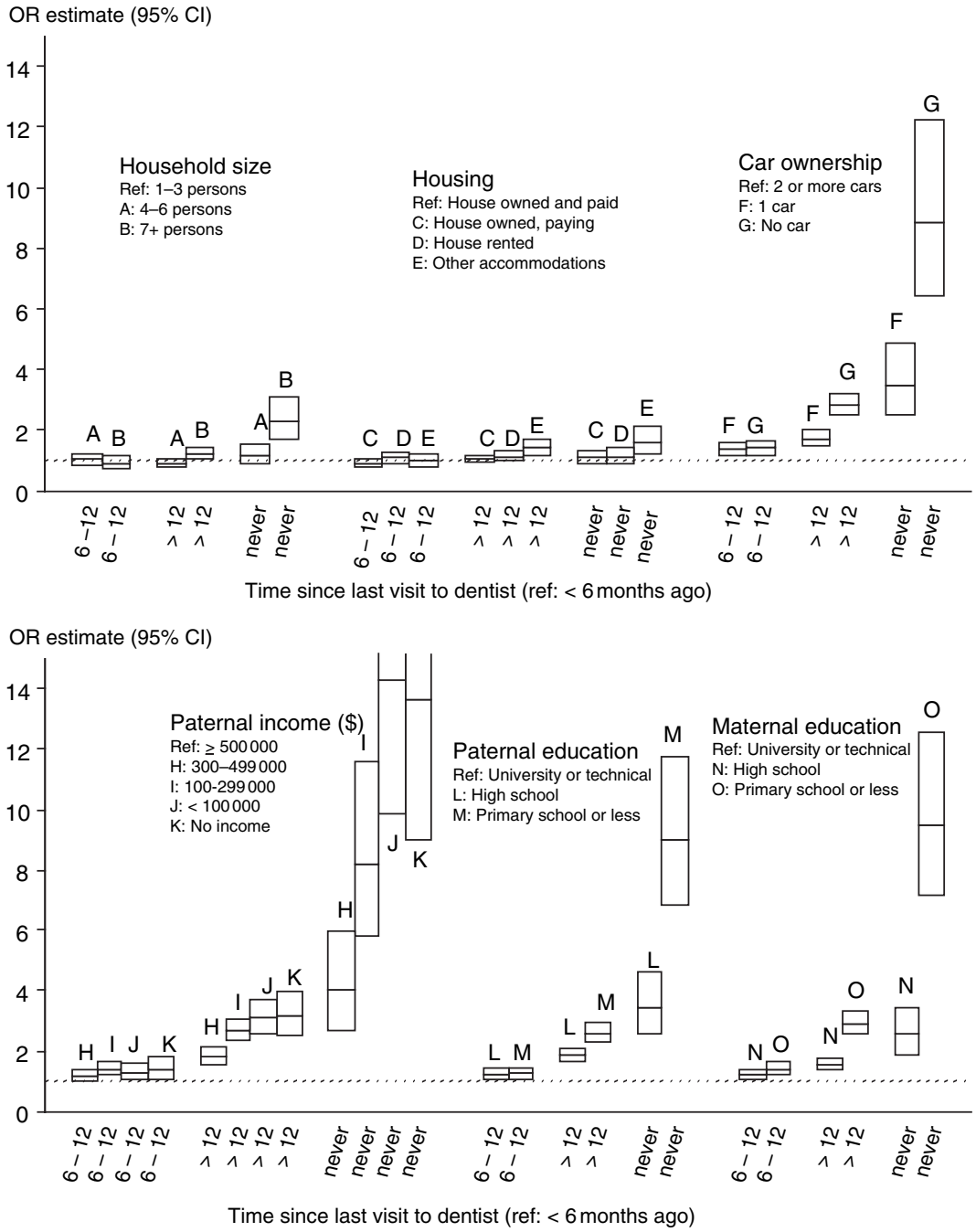

Fig. 2. Odds ratios for the association between the social variables included in the final logistic regression models and the variable time since last visit to dentist (95% confidence intervals included).

studies of children and young adults conducted under the auspices of one of the earlier classifications are interpreted as if they provide information about aggressive periodontitis (53, 54). This is problematic and serves only to add to the confusion regarding the diagnosis of periodontitis. The use in the present study of several definitions of periodontitis was thus an attempt to circumvent the diagnostic problem. Even so, our observation that a social gradient manifests itself whatever periodontitis definition was used is not wholly unexpected, as one would indeed expect the different periodontal outcomes to be related to one another.

It is frequently argued that the level of periodontal destruction must exceed some (arbitrary) threshold level before it can be considered a result of periodontitis. We strongly disagree. Teeth erupt to a full height of the periodontium, and in order to reach a particular level of severity, e.g. attachment loss in excess of 3 mm, the periodontal destructive

Table 3. The effect of misclassification on the observed association between NUG case status and the indicators of socioeconomic position estimated in logistic regression analyses

Determinants	β coefficient observed in final model	Mean (SD) value of β coefficient observed in 100 simulations		
		10% misclass	20% misclass	30% misclass
Size of household				
1–3 persons (Ref)	–	–	–	–
4–6 persons	0.13	0.02 (0.06)	0.01 (0.08)	0.03 (0.10)
7 or more persons	0.40	0.37 (0.07)	0.32 (0.09)	0.30 (0.11)
Not answered	0.53	0.50 (0.12)	0.44 (0.18)	0.38 (0.23)
Number of cars owned				
2 or more cars (Ref)	–	–	–	–
1 car	0.20	0.18 (0.06)	0.15 (0.08)	0.13 (0.11)
No car	0.31	0.29 (0.07)	0.24 (0.09)	0.21 (0.11)
Not answered	0.11	0.09 (0.10)	0.09 (0.13)	0.07 (0.19)
Income – father				
≥$500 000 (Ref)	–	–	–	–
$300–$499 000	0.22	0.19 (0.09)	0.15 (0.10)	0.10 (0.12)
$100–$299 000	0.28	0.23 (0.08)	0.19 (0.09)	0.16 (0.10)
<$100 000	0.45	0.40 (0.09)	0.34 (0.12)	0.28 (0.12)
No income	−0.00	−0.03 (0.11)	−0.04 (0.14)	−0.03 (0.16)
Not answered	0.25	0.22 (0.10)	0.16 (0.12)	0.14 (0.16)
Education–father				
Techn. or univ. comp. (Ref)	–	–	–	–
High school comp.	0.24	0.20 (0.07)	0.17 (0.08)	0.16 (0.10)
Up to primary comp.	0.50	0.44 (0.06)	0.39 (0.07)	0.34 (0.11)
Not answered	0.36	0.31 (0.11)	0.29 (0.13)	0.26 (0.18)

process must necessarily pass the stages corresponding to 1 and 2 mm attachment loss. In our understanding the threshold argument is based on one (or both) of two issues: it is either born out of considerations about the reliability of recordings of subtle changes (e.g. 1 mm attachment loss), or it originates in the idea that small attachment losses are not necessarily the 'effect' of periodontitis but could originate in tooth brushing trauma, etc. As regards the latter, it is our opinion that it is extremely hazardous to attempt to ascribe etiology to lesions based on their size. As regards the reliability issue, we have demonstrated that periodontal attachment loss may be diagnosed with a degree of reliability sufficient to warrant the considerations also of the more subtle levels of periodontal destruction (27).

In the present study the diagnosis of NUG was based solely on the presence of necrotic ulcerated lesions, and did not consider the signs of bleeding and pain, which are often included in descriptions of the signs and symptoms of NUG (55, 56). However, bleeding is common to other periodontal diseases and while it is probable that pain is a frequent symptom of NUG patients who seek treatment for their problem, it is less clear whether pain is important among NUG cases identified in epidemiological studies. Hence, Grupe and Wilder (57), and Barnes et al. (58) found that most NUG cases present only mild or no gingival pain. Additionally, in a comprehensive review of acute necrotizing ulcerative gingivitis, Johnson and Engel (59) warned against categorizing NUG too rigidly on the basis of gradation of symptoms, as we may fail to properly diagnose cases in subjects who do not present with all of the 'typical' signs and symptoms. It thus remains a fact that the necrotic ulcerated lesion is the only pathognomonic sign of NUG.

Much contemporary periodontal epidemiology is devoted to the identification of the proximal, biologic causes of periodontal disease occurrence among individuals (2). The results of the present study indicated that understanding and explaining the social gradient in periodontal disease occurrence may provide further insight into the mechanisms of periodontal disease causation. The models used when attempting to explain the social gradients in health include inequity in the distribution of medical care; health selection phenomena that make the sick drift down the social hierarchy; early life influences that determine socioeconomic position as well as general health status; differences in the susceptibility to the effects of specific biologic factors; social differences in health-related behaviors determining the exposure to biologic risk

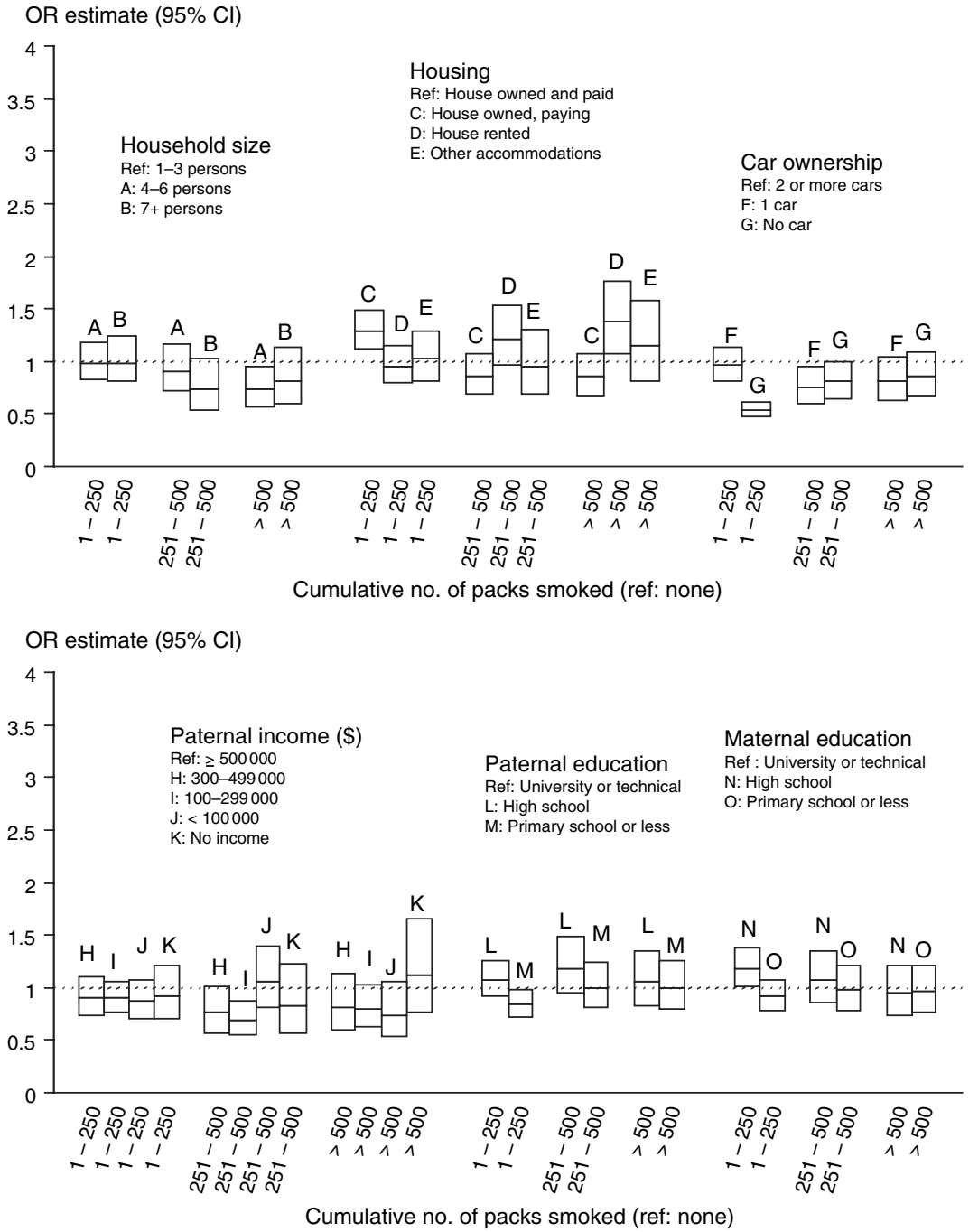

Fig. 3. Odds ratios for the association between the social variables included in the final logistic regression models and the variable cumulative number of packs of cigarette smoked (95% confidence intervals included).

factors; differences in material circumstances that make it impossible to avoid exposure to biologic risk factors; and, finally, psychosocial factors such as perceived low control, life stress and low social support (38). It is conceivable that several of these explanations may be valid for the present study population.

Paternal income and parental education appeared as the most influential social indicators in this study. While parental education may serve to reduce the risk of exposure to damaging factors and to reinforce protective health behaviors and psychosocial resources, higher paternal incomes in the Chilean society may additionally represent an improved access to dental health care. A possible explanation for the association between household size and the presence of NUG is residential crowding which, in turn, is related to stress and poor parental responsiveness (30). A complementary explanation may be an increased risk of transmission of infectious agents

resulting from residential crowding. These aspects of daily family life may also seriously influence the health-related behaviors.

Our findings suggest that the frequency of tooth brushing and the frequency of dental visits are indeed intermediate steps linking socioeconomic position and periodontal diseases (Figs 1 and 2). However, it is difficult to disentangle the specific effects of these behaviors. While the association may indicate that subjects who go to the dentist or brush their teeth more often are less likely to have periodontal diseases because they benefit directly from these behaviors, it is also possible that dental visits and tooth brushing habits serve as markers of a lower exposure to other risk factors. Certainly, a sizeable portion of Chilean adolescents cannot afford dental visits or even a personal toothbrush indicating that the questions 'when did you last visit a dentist' and/or 'how often do you brush your teeth' capture social dimensions beyond those of health-related behaviors.

At a first glance, the lack of association between smoking and the socioeconomic position indicators under study may seem surprising in view of the many reports indicating an association between socioeconomic position and smoking among adults. However, the relationship between smoking and socioeconomic position is particularly complex among adolescents, because the above trend is countered by the fact that the smoking initiation rates are inversely related to socioeconomic position indicators (44). Hence, adolescents need to be able to afford the cost of cigarettes in order to be regular smokers (44, 60–63).

A recent review of the epidemiology of periodontal diseases among adolescents quotes prevalence estimates for 'aggressive periodontitis' in the range from 0.02% to 3.81% (53), consistent with the notion that these forms of periodontal diseases are rare among adolescents (1). The results of the present study indicate that the prevalence of periodontal conditions that conform with the diagnostic label 'aggressive periodontitis' (24) in an ethnically rather homogeneous population (64) may vary to a similarly large extent depending solely on the socioeconomic position of the subjects (Table 1). This, in turn, shows the difficulties involved when attempts are made to infer that observed disparities in periodontal diseases across the world's populations have a race–ethnic background (53).

It is occasionally argued that the association between health status and socioeconomic position may arise because ill-health leads to a drift toward lower socioeconomic position, thereby being the consequence of 'reverse causation' (43). However, even though some health-related social mobility may occur, reverse causation does not seem to play any significant role in explaining the existence of a social gradient in health (45, 65). Moreover, in studies such as the present, the reverse causation model is even more unlikely as an explanation for the social gradient, because the adolescents' socioeconomic position is measured using parental social indicators. It is thus quite inconceivable how the occurrence of periodontal diseases in the adolescents should influence the achieved education, income, and wealth of their parents. The use of adolescents' reports of parental socioeconomic indicators has been found to be adequate (66–68), with adolescents as young as age 13 or 15 years being able to provide valid and reliable answers to questions on their parents' socioeconomic position (66). The main limitation of the use of those indicators is a usual poor completion rate (66, 67); however, this was not the case in the present study (Table 1).

In conclusion, the present study has demonstrated the existence of a strong social gradient in periodontal disease among adolescents. The strength of this gradient is such that it would be able to account for the differences observed across various ethnic groups (53) in the prevalence of aggressive periodontitis. Particularly worrying is the fact that the social gradient in periodontal diseases may reveal itself already in adolescence.

Acknowledgements

The authors appreciate the valuable advice received from Prof. Michael Vaeth of the Department of Biostatistics of the University of Aarhus concerning the analyses and presentation of the data. They are also grateful to Ms Marta Valdenegro from Hospital El Salvador, Santiago, Chile for her helpful assistance in the selection of the social indicators to be included in the study in order to measure different dimensions of social inequality. The study was partially supported by a grant from the Danish Medical Research Council.

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