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A socio-economic perspective on periodontal diseases: a systematic review

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Abstract

Objective: The aim of this systematic review was to ascertain whether socio-economic conditions increase the risk of periodontal diseases.

Methods: A MEDLINE search was conducted for the period 1965–April 2004. Only original articles were included; 47 studies remained for the final assessment. The studies were analysed regarding the outcome of the association between socio-economic variables and periodontal disease, depending on the study design (cross-sectional survey or longitudinal case–control) and whether smoking was included or not.

Results: Twenty-nine out of 36 studies with a cross-sectional design were in favour of the association between socio-economic factors and periodontal diseases. In the studies with a longitudinal or case–control design, there were five in favour of the association, and also six against. When smoking was included in the analysis of cross-sectional studies, a significant association between socio-economic variables and periodontal disease was found in 11 studies and no significance in another five studies. The corresponding figures for case–control studies showed four studies being significant, but also four studies showing no significance.

Conclusion: Based on relevant study designs and including smoking in the analysis, the socio-economic variables associated with periodontal diseases appear to be of less importance than smoking.

Key words: periodontal disease; socio-economic factors; systematic review

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Several factors such as genetic (age), co-morbidity (diabetes mellitus, DM) and lifestyle (smoking) have been identified to possess a risk for periodontal diseases in published studies (Page & Beck 1997, Albandar 2002).

Age as a risk for attachment loss has been well documented in many studies from different countries with different cultural traditions and economic welfare, i.e. the genetic risk of periodontal diseases is obvious (Carlos et al. 1987, Goodson 1992, Wennström et al. 1993, Papapanou 1996, Norderyd & Hugoson 1998, Sheiham & Netuveli 2002).

Co-morbidity like DM increases the risk of periodontal diseases by almost 50%, compared with non-DM individuals (Papapanou 1996, Sandberg et al. 2000).

One obvious risk factor of periodontal diseases originates from lifestyle, for example, smoking. Several studies have confirmed the highly increased risk of smoking more than 10 cigarettes per day, estimated to an increased risk of about 100%, compared with the average risk of the population (age adjusted) (Bolin et al. 1993, Grossi et al. 1994, Norderyd 1998).

The above-mentioned three groups of risks for periodontal diseases are nowadays not controversial. However, the group of risk factors defined as socio-economic risk factors is more controversial. Some studies lend support to the perception that differences of socio-economic aspects play a major part in the development of periodontal diseases (Halling & Bengtsson 1984, Brown et al. 1994, Elter et al. 1999), whereas other studies cannot confirm this risk (Gelskey et al. 1998, Moore et al. 1999).

Aim of the Study

In order to find out whether socio-economic conditions increase the risk of periodontal diseases, a systematic review of published studies was undertaken.

Questions of interest for this systematic review were as follows:

- Is there an association between socio-economic developments in general and increased risk of periodontal diseases?

- What socio-economic variables in particular are associated with the highest risk of periodontal diseases?
- Are different socio-economic variables of importance for increased risk of periodontal disease in different countries?
- What is the importance of socio-economic factors on periodontitis over time?

Definition of Socio-economic Variables

In this review, a rather wide perspective on socio-economic variables is used including income, occupation, education, unemployment, social class, living conditions and race.

Demographic variables such as gender, age and nationality of study population were also considered to be of interest.

Literature Search

Based on the following search strategy, the literature search was undertaken in Medline for the period 1965–April 2004: ''Periodontal Diseases'' [MeSH:-NoExp] OR ''Alveolar Bone Loss'' [MeSH] OR ''Furcation Defects'' [MeSH] OR ''Periodontal Attachment Loss'' [MeSH OR ''Periodontal Cyst'' [MeSH] OR ''Periodontitis'' [MeSH] OR ''Tooth Mobility'' [MeSH] AND ''socioeconomic factors'' [MeSH terms], limits. All adult: 19+ years, Human AND (''epidemiologic studies'' [MeSH Terms] OR ''epidemiology'' [MeSH Subheading] OR ''cohort'' [Text Word] OR [case–control'' [Text Word] OR ''cross sectional'' [Text Word] OR ''relation'' [Text Word] OR ''relationship'' [Text Word] OR ''association'' [Text Word] OR ''dental health surveys'' [MeSH Terms] OR ''epidemiologic methods'' [MeSH Terms]) Limits: All Adult: 19+ years, Human NOT (''case reports'' [Publication Type] OR ''comment'' [Publication Type]) NOT ''editorial'' [Publication type] NOT (''letter'' [Publication Type] OR ''news'' [Publication Type]) limits: All adult: 19+ years, Human.

The retrieved references were evaluated by both authors. Any article considered to be of significance by at least one author, which answered the questions of this review, was ordered in full text. The literature search gave 281 abstracts, of which 126 were commanded in full text. Sixty-six studies were considered relevant for the systematic review. After further reading, 47 studies remained for the final assessment.

As described above, only original articles were included; thus, double publications, editorials, letters and reviews were excluded. No specific quality assessment was made of each study since the majority of the studies had a cross-sectional design, and/or were general surveys, often with high dropout rates. Following the aim of transparency of this process of systematic review, each study was given a short description, and the characteristics of each study are presented in Table 1. Finally, the studies were analysed regarding the outcome, i.e. the association between socio-economic variables and periodontal diseases, depending on the study design, and whether smoking was included in the respective study or not.

Results

Description of the studies

Body weight, calculated as body mass index (BMI), as a risk factor of periodontal diseases was studied by Al-Zahrani et al. (2003), based on the Third (1988–1994) National Health and Nutrition Examination Survey (NHANES III) in the USA. The cross-sectional design is, however, a limitation for the association of causality. Differences in the prevalence of periodontitis between the high poverty index (''rich'') and low poverty index (''poor'') were, reported, i.e. 10.84% *versus* 19.24%, or between education >12 and <12 years, i.e. 9.02% *versus* 21.65%. BMI showed a significant difference but only as regards those aged 18–34 years: BMI <18.5 had an adjusted odds ratio (OR) of 0.21 (95% confidence interval (CI) was 0.085–0.565) *versus* BMI >30 with an adjusted OR of 1.76 (95% CI was 1.19–2.61). The adjustment was made for gender, race, smoking, poverty index, education, diabetes and the time since last dental visit.

In a longitudinal random sample study from the USA of people aged 65+ years, Beck et al. (1997) studied education less than 12 years as a socio-economic variable of importance for periodontitis. The dropout rate was high, 55%, during the 5-year study based on interviews and examinations in the homes of the participants. Smoking was one important risk factor of attachment loss, but so was education <12 years that had an OR of 1.8 and a 95% CI of 1.4–2.4.

A cross-sectional study was undertaken in Melbourne by Bergman et al. (1991) to test different propositions about the oral health needs of the elderly. The included subjects were 60+ years old. University education was associated with lower incidence of periodontitis. Smoking was not included in the analysis.

Historical disparities in periodontal status were studied by Borell et al. (2002) based on the First (1971–1974) *versus* the Third (1988–1994) NHANES (I *versus* III) in the USA. The surveys were based on stratified samples of 17,000–18,000 inhabitants, but data on tooth scoring were obtained from 1/3 of the sample only. The socio-economic variable was black *versus* white, a racial variable that might cover not only educational differences but also income differences. Controlled for several variables (age, sex, marital status, self-perceived health, medical insurance, diabetes, tobacco use), the prevalence ratio because of racial differences increased from 1.22 to 1.83.

In another study by Borrel et al. (2003), a cross-sectional study in the Detroit area, the effects of race on established periodontal diseases prevalence were analysed. When adjusted for several covariates, socio-economic factors such as income, education and employment status, the effects of race still remained significant. Smoking was included as a variable, but only current smoking.

In a combined survey and physical examination concerning periodontal health, Bourgeois et al. (1999) studied 603 adults of 65–74 years of age chosen randomly from a stratified sample. A synthetic socio-economic variable based on education, occupation and income indicated that the prevalence of periodontal diseases was lowest among adults of medium socio-economic status. Smoking was not included as a variable.

In a prospective, cross-sectional study of diabetic *versus* non-diabetic men from the USA, the effects of smoking, glycaemic control and socio-economic factors were studied by Bridges et al. (1996). The design was a case–control study and it had only one examiner. There was no difference between diabetic and non-diabetic men with respect to the effects of the socio-economic factors studied. From a multiple regression analysis, it was shown that income

Table 1. Periodontitis–socio-economic risk factors

Author, Country, Year	Topics regarding periodontitis	Socio-economic risk factors in focus	Study design	Population	Assessment of periodontitis	Main socio-economic results	Other results and remarks
Al-Zahrani, USA, 2003	Body weight (BMI)	Education, poverty index	Survey NHANES III	>18 years *n* = 17,752 Women 51.2%	Attachment loss >3 mm Probing depth >4 mm	Prevalence of periodontitis – education: >12 years: 9.02% <12 years: 21.65% poverty index: <1.30: 19.24% >2.75: 10.84%	BMI: prevalence of periodontitis underweight <18.5: 9.15% normal 18.5–24.9: 11.55% overweight 25–29.9: 14.59% obese >30: 17.65% Smoking included
Beck, USA, 1997	Demographic, smoking, dental examination	Education <12 years black *versus* white	Longitudinal random sample, 5 years Interviews+ examinations at home	65+ years 818 from start, 540 at the end	Attachment loss >3 mm	Education <12 years OR 1.8 (CI 95%) 1.4–2.4	High risk of attachment loss also from smoking, *Porphyromonas gingivalis*-positive, >5 missing teeth, no dental visit in 5 years
Bergman, Australia, 1991	Test different propositions about the oral health needs of the elderly	Previous occupation, education	Cross-sectional randomly selected in Melbourne, aged 60+. Questionnaire Dental control (no radiology)	303 citizens, 70% women, 60+ years	CPTIN	If education from university, or non-manual work, lower frequency of lost teeth. No significant association with periodontitis	Low frequency of need for complex periodontal service Smoking not included
Borell, USA, 2002	Demographic, medical history, dental examination, health needs	Black *versus* white	Surveys, NHANES I and III, 1971–1974 and 1988–1994, using periodontal index scoring, 14 teeth per individual	Stratified sample included >17 years, *n* = 17,030 *versus* *n* = 18,162 Women 52.2%	Attachment loss >3 mm Pocket depth >4 mm	OR (CI 95%) 1.31 (0.78–2.19) in 1971–74 and 2.09 (1.68–2.60) in 1988–94	Controlled for age, sex, marital status, self-perceived oral health, medical insurance, diabetes, tobacco use; because of the racial difference, the prevalence ratio increased from 1.22 to 1.83
Borell, USA, 2003	Periodontitis as a racial effect	Education Income Employment status	Cross-sectional interviews Dental control	1108, of whom 787 participated, and 455 to the end Women 52.3%	CAL >4 mm and at least one site with PD >4 mm	In multivariate analysis, income and education were not significantly associated with periodontitis	Frequency of dental check-up important for prevalence of periodontitis Smoking and diabetes were included in analysis
Bourgeois, France, 1999	Assess the periodontal health status of elderly, 65–74 years	Socio-economic level (occupation, education, household income)	Survey and clinical examination, stratified sample	603 subjects of 380,456 non-institutionalizd Women 58.5%	CPITN	Adults from medium economic class had fewer deep pockets	Urban residence living had lower prevalence of periodontal disease than rural living Smoking not included
Bridges, USA, 1996	Diabetic *versus* non-diabetic men: effects of smoking, glycaemic control and socio-economic factors	Income, education	Recruited from outpatient clinics Survey plus clinical examination Prospective, cross-sectional	Men 24–78 years, matched patients regarding age and BMI only. Diabetic men *n* = 118, non-diabetic *n* = 115 examination,	Attachment level CAL Probing depth	Income and education were associated negatively with periodontal status, as presented from multiple regression	No difference in non-diabetic *versus* diabetic men with respect to the effects of socio-economic measures Smoking had a distinct effect on all parameters of periodontal status
Brodeur, Canada, 2001	Periodontal disease in adults, 35–44 years	Income	Random sample, dental questionnaire	*n* = 2110, but only 44.5% participated	CPITN	Income <$ 30,000 had an RR 2.0 of having at least one tooth with a periodontal pocket >6 mm	Smoking not included

Brown, USA, 1994	Attachment loss among 65+ years living in the community	Education, <12 years or >12 years	Longitudinal random sample, 18 months follow-up, interviews + dental examinations	$n = 1018$ attrition 200 during 18 months 65+ years, Women 59.3%	Attachment loss >3 mm	Logistic analysis: no significance Bivariate: whites >12 years of education had lower risk of periodontitis	Low predictive value of predictive aetiologic models
Bullock, England, 2001	Regular dental visits *versus* non-regular, and mobility of teeth and bone loss	Social class	Case–control at one dental practice, consecutive patients, bitewing radiographs	Patients aged 18+ years, 100 casual, 100 regular attenders Women 54.5%	Bone loss >30%	Regular attenders from higher social classes and had lower frequency of tooth loss and bone loss than lower social class (16% *versus* 29%)	Casual attenders were three times more likely to be smokers, compared with regular attenders
Craig, USA, 2001	Risk factors, genetic or socio-economic confounders	Occupational status, formal education	Selected from NY University College of Dentistry, convenience sample	56 Asian American, 71 African American, 58 Hispanic subjects Women 66.1%, 42.3% and 41.4%, respectively	Pocket depth Attachment level	African Americans had the most severe periodontitis, also the highest frequency of unskilled occupation, but also the highest frequency of smokers	Unskilled subjects were older, had higher levels of attachment loss and had the highest current smoking history (<0.01) compared with professional subjects
Demetrion, Greece, 1995	Compliance with supportive periodontal treatment of socio-economic classes	Socio-economic classes I–III	Retrospective 1977–1991 Longitudinal	521 patients at one dental office Women 63.5%	Periodontal treatment	Non-significant compliance dropout between social classes	Gender, but not social class, showed significant difference
Dolan, USA, 1997	Socio-demographic risk indicators of attachment loss	Education, income, residence	Cross-sectional, interview, clinical examination	Ages 45+ years $n = 873$ out of 1800 invited Women 54%	Attachment loss	Residence, education, income associated with severe attachment loss	Gender, race, flossing, smoking, diabeties were also associated with severe attachment loss, i.e. multifactorial
Drake, USA, 1991	SES *versus* dental need	Education level, Duncan socio-economic index, place of residence	Cross-sectional, interviews, dental examinations	Adults 65+ years, random sample, 616 out of 1019 completed	CPITN	Blacks, OR: education 2.2 residence 1.8 whites, OR: education 4.1 socio-economic index 4.4	Tobacco use OR 2.3 and 2.5 for blacks and for whites
Drury, USA, 1999	Socio-economic disparities in adult oral health	SES (education and economic status)	NHANES III survey data 1988–94	14,000+ subjects 18+ years	Attachment loss >4 mm	Lower SES had 33.3% AL >4 mm compared with 20.6% in higher SES	Lower SES had LR 7.2 of untreated root decay than higher SES Smoking not included
Dye, USA, 2002	Socio-demographic characteristics of periodontal treatment need	Education, race (non-hispanic blacks)	Cross-sectional, dental examination	NHANES III survey, 11,339 out of 16,993 participated, 20–79 years with >6 teeth Women 50.6%	CPITN index	Non-Hispanic blacks: OR 2.5 No high school: OR 2.1 for increased complex periodontal treatment needs	Only 3% of the population has complex periodontal treatment needs Smoking OR 2.0
Elter, USA, 1999	Self-perceived oral health *versus* socio-demographics	Education (<12, >12 years) Income	Longitudinal five examinations in 7 years, random sample, Interviews	65+ years, $n = 697$ from start but only 186 remained after 7 years Women 58.1%	Attachment level	Education <12 years for whites, IDR 1.6	Smoking IDR 1.4–1.9 Never had dental check-up IDR 1.4–1.9

Table 1. (Contd.)

Author, Country, Year	Topics regarding periodontitis	Socio-economic risk factors in focus	Study design	Population	Assessment of periodontitis	Main socio-economic results	Other results and remarks
Gamonal, Chile, 1998	Periodontal status in demographic settings	SES, Education	Cross-sectional random-stratified sample clinical examination interview	Ages 35–44 and 65–74, $n = 1150$ of whom 1096 participated Women 52.9%	CPITN	Pocket depth >6 mm low SES 60.9% middle SES 31.7% high SES 15.3% Education also significant	Association between educational level and loss of teeth Smoking not included
Gelskey, Canada, 1998	Adult periodontitis and health-compromising behaviors and socio-economic factors	Education Occupation Income Employment	Retrospective case–control clinical and radiographic data Interviews by telephone	Adults 35–87 years, age-stratified $n = 205+205$ Women%	Attachment level >3 mm	Included socio-economic variables had no significant OR with periodontal disease	Being single OR 1.77, also increased with age
Grbic, USA, 1991	Risk indicators for clinical attachment loss	Education, occupation	Consecutive patients at dental school Dental control, questionnaire	$n = 75$ patients 30–69 years Women 54.7%	Attachment loss	None significant	Age highly significantly associated with clinical attachment loss Small selected group Smoking not included
Grossi, USA, 1994	Risk indicators for attachment loss	Education, Income, SES	Cross-sectional Random samples	$n = 1426$ subjects 25–74 years Women 52%	Attachment loss	Adjusted for age, diabeties and smoking; there was no effect of socio-economic variables	Dose-dependent risk of increase from smoking
Gugushe S., Africa, 1998	Influence of socio-economic variables on prevalence of periodontal disease	Income, race, education	National Oral Health Survey 1988–89 Retrospective analysis	$n = 3763$ 20–64 years	CPITN	Whites, high income and high education associated with periodontal disease	Retrospective analysis Smoking not included
Halling, Sweden, 1984	Socio-economic impact on dental status	Socio-economic groups, education, rural *versus* urban living	Cross-sectional and Longitudinal	$n = 1,462$ women in age strata Women 100%	Bone score	Education and socio-economic group associated with edentulous women	Smoking not included
Hansen, Norway, 1995	Socio-ecologic variables associated with periodontal disease	Education, economic situation	Longitudinal survey 1973 and 1988	$n = 116$ 35 year old inhabitants in Oslo Women 46.6%	PTNS	Short education OR 2.06 for periodontal disease	Also, behaviour and environment associated with risk of periodontal disease
Hobdell, WHO data, 2003	Socio-economic characteristics and periodontal disease	Time at school Human development National product Gini coefficients	Analysis of national databases	35–44 years old in 44 countries	CPITN	CPITN correlation 0.43–0.53 to SES	Structural factors in society affect oral disease Aggregated data from different counties and years
Horton, USA, 1968	Educational level as a predictive factor	Individual education	Subjects selected from enlisted in Fort Carson, Colorado	Men 17–52 years, $n = 1284$	Periodontal Index	Those aged 22–29 years showed significant association between educational levels and periodontal index	No geographical differences Selected group Smoking not included No statistical calculations included
Hujoel, USA, 2003	Prediction of periodontal disease for 2020	Education	NHANES III, ages 30–39 Prognostic model	US population 30–39 years	Probing >depth 5 mm	Education level inversely related to periodontal disease	Incidence of advanced periodontal disease could decrease 68% if smoking were to be eliminated

Ismail, USA, 1987	Periodontal disease among Hispanics	Poverty status	HHANES I Dental examination	$n = 3860$ Mexican Americans 18–74 years Women 55.7%	Periodontal pockets	Below poverty status for 25–44 years associated with periodontal Pockets	Overall more gingivitis but less periodontal pockets than in the general population Smoking not included
Lang, USA, 1994	Effects of prevention on periodontal health	Income, education	Interviews and dental examination Cross-sectional	$n = 662$ (72%) and $n = 397$ included in control Women 55.7%	Attachment loss	Income < $20,000 and education <11 years associated with attachment loss	Age, gender and race also significantly associated with periodontal disease Smoking not included
Locker, Canada, 1993	Risk markers for periodontal disease	Education, household income	Telephone survey and dental examination Longitudinal study	50+ years $n = 3,033$ telephone $n = 907$ dental control Women 54.7%	Attachment loss	Linear regression: no significance Logistic regression: education OR 0.5	Smoking the most important factor for periodontal disease OR 2.6, besides age, OR 3.4
Markanen, Finland, 1980	Socio-economic factors associated with periodontal treatment needs	Education, income	Surveys and clinical control at one paper mill	$n = 315$ of whom $n = 279$ participated ages 18–65	PTNS	Multivariate: of 28.3% explained variance of dental status	One workplace Smoking not included
Markanen, Finland, 1983	Socio-economic factors that affect periodontal treatment needs	Education, income	Part of Mini-Finland Health Survey	$n = 8,000$, of whom $n = 7,162$ participated ages 30+	PTNS	Multivariate: of 38.1% explained variance education had 1.7%	Smoking not included
McGrath, England, 2002	Perceived oral health of the public	Social class	National survey	$n = 3000$ but $n = 1865$ participated	Subjective assessment only	Social class	Smoking not included No oral control
Micheelis, Germany, 1996	Socio-demographic patterns on attachment loss	Region SES	Cross-sectional in 1989 and in 1992	$n = 1741$ in 1989 and $n = 1519$ in 1992, ages 8–54	Attachment loss	CPITN >6 mm was 25% and 17%, former East *versus* West Germany, SES 12% *versus* 21%	Smoking not included
Moore, USA, 1999	DM T1 and periodontal disease	Education income	Longitudinal Interview and dental	$n = 406$ DM since >32 years Women 44.4%	Attachment loss	No significance of socio-economic factors	Age (OR 3.0), >8.5 years since onset of DM (OR 3.4) and smoking (OR 9.7)
Mumghamba, Tanzania, 1995	Socio-economic effects on periodontal disease	Education, residence	Cross-sectional, interviews and oral control	$n = 1942$ ages 3–84 Women 53.1%	Periodontal pockets	Rural residence had OR 3.5	Smoking had no significant OR for periodontal pockets Chewing ''mswaki'' had effects?
Nikias, USA, 1977	Economic status and education associated with periodontitis	Income, education	Screening of families enrolled in	$n = 2787$ but $n = 1290$ participated	Periodontal pockets	Limited education was associated with periodontitis	Economic status has its strongest association with restored teeth Smoking not included
Norderyd, Sweden, 1998	Risk factors for severe periodontal disease	Income, education	Cross-sectional, clinical and radio-graphic	$n = 552$ 20–70 years patients at dental school Women 51%	Alveolar bone loss	Univariate: income increased risk Multivariate: no significance	Smoking >10 cigarettes per day OR 11.84, Age OR 1.17
Palmqvist, Sweden, 1986	Socio-economic conditions and oral status	Actual and relative income, willingness to pay	Cross-sectional	$n = 500$, $n = 305$ had dental control $n = 158$ interviewed by telephone Women 55%	Periodontal pockets	No socio-economic variable was significant	Willingness to pay had no correlation to periodontal status
Paulander, Sweden, 2003	Educational level and oral health status	Education	Cross-sectional	$n = 1,093$ ages 35–75 Women 51%	Attachment loss CPITN	Education but only <65 years, Age + education not significant	Smoking not included

Table 1. (Contd.)

Author, Country, Year	Topics regarding periodontitis	Socio-economic risk factors in focus	Study design	Population	Assessment of periodontitis	Main socio-economic results	Other results and remarks
Persson, USA, 1998	Association of oral conditions *versus* income and education	Income, education	Longitudinal 3 years, selected patients	$n = 295$ 60+ years Women 54.6%	Probing depths	No significant association	Women on hormone replacement therapy had fewer sites of PDs >5 mm Smokers had deeper PDs
Plasschaert, The Netherlands, 1978	Education associated with periodontal disease	Education	Cross-sectional	$n = 1500$ and $n = 1337$ Women 42.1%	Periodontal pockets >3 mm	Education: low, middle, high had 2.4%, 1.9% and 1.7%, respectively	Smoking not included
Shah, India, 2003	Gender and socio-economic differences *versus* periodontitis	Socio-economic class, gender	Screening in rural and urban areas cross-sectional	$n = 716$ urban $n = 524$ rural 60+ years Women 42.7%	CPITN	No significant socio-economic difference	Highly skewed frequency in men *versus* women of previous treatment because of gender differences
Teng, Taiwan, 2003	Lifestyle and psychosocial factors *versus* periodontitis	Income, occupation, education	Matched case–control survey and dental control	$n = 250+250$ Mean age 42.8 and 42.3 Women 46%	Attachment loss	Adjusted for age and smoking, no socio-economic variable significant	Clear dose–response of toothbrushing frequency, mental stress and smoking
Treasure, England, 2001	Periodontitis caused by social class	Social class I–IV, education attainment	National survey, dental control	$n = 6204$ ages 16–64	Attachment level	Low education level	More complex socio-behavioural factors are at work than social class structures only Smoking not included
Turunen, Finland, 1993	Socio-economic factors *versus* dental health	Gender, education income, occupation, marital status	Cross-sectional survey, dental control	$n = 1200$ but $n = 909$ participated	CPITN	Gender OR 3.0, education OR 2.6 marital OR 2.2	Smoking not included
Unell, Sweden, 2000	Socio-economic aspects on peridontitis	Gender, education marital status, working hours	Cross-sectional	$n = 8888$, $n = 6343$ participated	CPITN	Socio-economic variables had no significance	Smoking was significant in all cases

BMI, body mass index; NHANES, National Health and Nutrition Examination Survey; CPITN, community periodontal index for treatment need; OR, odds ratio; CI, confidence interval; PTNS, periodontal treatment needs; SES, socio-economic status; CAL, clinical attachment level; PD, probing depth; DM, diabetes mellitus; HHANES, Hispanic Health and Nutrition Examination; IDR, incidence density rate.

and education were associated negatively with periodontal status.

A cross-sectional study in Quebec included 2110 subjects, but $>50\%$ dropped out before the dental control. Brodeur et al. (2001) found that income $<\$30,000$/year increased the risk (RR 2.0) of having at least one tooth of periodontal pocket >6 mm. Smoking was not included in the analysis.

The incidence of attachment loss for people living at community dwellings was studied by Brown et al. (1994) in a longitudinal study. The socio-economic variable considered as most important according to the hypothesis of the study, education, was, however, not significant in the logistic model, but only in the bivariate analysis and then only for whites (education >12 years, OR 2.0). The authors also concluded that the value of predictive models of periodontal diseases was limited.

In a case–control study from one dental practice, $100+100$ consecutive patients were studied as regards alveolar bone loss. Bullock et al. (2001) found that regular attendees had significantly less alveolar bone loss (16%) than the casual attendees (29%). Regular attendees came from higher social classes, and casual attendees came from lower classes. The result was adjusted for age, gender and smoking.

A study based on a convenience sample ($n = 185$) from subjects attending a college of dentistry in New York was undertaken by Craig et al. (2001). The issue studied concerned whether differences of periodontal status were because of genetic factors, or socio-economic status. The socio-economic variable ''unskilled worker'' had a significantly higher share of bleeding on probing than the professional group, but the unskilled worker group also had a significantly higher age and current smoking, compared with the professional group.

The compliance to supportive periodontal treatment for different socio-economic classes was studied retrospectively by Demetriou et al. (1995). The subjects were all patients at one private dental office in Athens. Patients in the highest social class had the highest compliance rate after 8 years, i.e. 61.5%, compared with 41.4% for the lowest social class ($p<0.017$). Smoking was not included in the analysis.

Socio-demographic risk indicators of attachment loss were studied by Dolan et al. (1997) in a cross-sectional study,

combining interviews with clinical controls. Less than 50% of the selected sample of subjects participated. Low income and rural living were associated with increased risk of attachment loss. Current smoking and DM increased the risk of having severe attachment loss, OR 1.9, compared with non-smokers and non-diabetics.

Drake et al. (1991) studied the effect of socio-economic variables on attachment loss. In this cross-sectional study, the socio-economic variables education, socio-economic index and place of residence were analysed for subjects aged 65+ years. Educational level had a high association with attachment loss, OR 2.2–4.1 for blacks and whites, respectively. The socio-economic index for blacks had an OR of 4.4, i.e. higher than for tobacco use, OR 2.5.

Socio-economic status inequalities in oral health were analysed from the NHANES III survey by Drury et al. (1999). Neither smoking status nor DM was included. Lower socio-economic groups were seven times more likely than higher socio-economic groups to have untreated root decay, but the differences were less apparent as regards attachment loss >4 mm.

The NHANES III survey was also used in a study on socio-demographic characteristics (Dye & Vargas 2002). Adjusted OR for complex periodontal treatment need was high for lower education, no high school (OR 2.10), and for ethnics, non-Hispanic blacks (OR 2.51). Apart from these socio-economic variables, age and especially smoking also had high OR (2.02).

A longitudinal (7 years) study based on a random sample of 697 subjects aged 65+ years was designed to develop aetiologic models for periodontal attachment loss. Elter et al. (1999) found that as concerns socio-economic factors, only the variable ''whites with education <12 years'' was significantly associated with higher levels of attachment loss. Smoking entered as an important factor, but more so for blacks than for whites.

A stratified cross-sectional sample of 1150 Chileans were interviewed and had a dental control in order to explore the association between socio-economic factors and periodontal health. Age groups 35–44 and 65+ years were studied. Gamonal et al. (1998) found that low socio-economic status, as well as a low level of education, were significantly associated with a high percentage of pocket depths >6 mm. Smoking was not included in the analysis.

Gelskey et al. (1998), in a case–control study based on retrospective clinical and radiographic data, combined with structured interviews by telephone, studied factors associated with increased prevalence of periodontal diseases. The setting was a university dental clinic, thus with a possible selection effect on patients. After adjustment for age and gender, smoking was the important risk factor for periodontal diseases. None of the included socio-economic factors (education, occupation, income, employment) increased the risk for periodontal diseases.

Patients at a university dental clinic were followed for 6 months. Grbic et al. (1991) found, in this study without controls, that age was significantly associated with periodontal diseases, but none of the included socio-economic variables.

Grossi et al. (1994), in a study of 1426 subjects 25–74 years of age, found no significant effect of socio-economic variables after adjusting for age, DM and smoking. A remarkable result was the dose-dependent risk increase from smoking.

In a retrospective analysis of a previously undertaken national oral health survey, Gugushe (1998) found a significant influence of income, education and race on the prevalence of periodontal diseases. Smoking was not included in the analysis.

Elementary school as only education, and belonging to social group III (lowest), were significantly associated with edentulous women, in a cross-sectional study of five age strata of women (Halling & Bengtsson 1984). Smoking was not included in the analysis.

In a follow-up study, Halling & Bengtsson (1984) studied the two age groups 38 and 50 years, after 12 years from baseline. A lower level of education continued to be significant for fewer remaining teeth. In neither of the follow-ups was smoking included.

A longitudinal small Norwegian study conducted a follow-up after 15 years of a cohort of 35 years old citizens from Oslo (Hansen et al. 1995). A socio-ecologic model including variables of environment, health care organization, human biology and behavioural factors, which also included smoking, was used in a logistic regression analysis. The behavioural factor ''no inter-dental cleaning'' had an OR of 3.65, and the environmental factor ''<10 years at school'' had an OR of 2.06 for an increase in periodontal treatment needs.

An international comparison of socio-economic status and oral health, including periodontal health, was conducted by Hobdell et al. (2003) based on databases from 44 countries. The result of the analysis was an R^2 of between 0.41 and 0.53 for socio-economic status and periodontal diseases. The problem with this kind of ecological study, based on aggregated national data, is the issue of controlling for confounders and co-linearity of variables.

In an early study (from 1968) of enlisted men aged 17–52 years, Horton & Sumnicht (1968) studied the association between educational levels and periodontal diseases progression as expressed from the Periodontal Index. The study showed that educational level had a significant (<0.01) importance for periodontal diseases for the age group 22–29 years, but not at all for those older than 29 years. Smoking was not included in the analysis.

Based on the results of the NHANES III data, a prognosis for the year 2020 was made by Hujoel et al. (2003). The authors found education to be inversely related to periodontal diseases. However, if smoking were to be eliminated in the population, 68% of the incidence of advanced periodontal disease could be eliminated, according to the speculation by the authors.

The association between poverty status and periodontal pockets was studied by Ismail et al. (1987) among Mexican-Americans, using the Hispanic Health and Nutrition Examination survey (HHANES, $n = 3860$). Individuals aged 25–44 years and belonging to a lower poverty status were significantly associated with periodontal pockets. However, smoking was not included in the analysis.

Effects of prevention on periodontal diseases and the relations to socio-economic variables were studied by Lang et al. (1994). In a two-phase project on effects of tooth-brushing, flossing and dental check-up of 920 subjects were included, of which only 397 completed the second phase of dental control. Only frequencies of dental check-ups varied between the socio-economic groups. Flossing varied with age, but tooth-brushing was not related to any variable.

Risk markers for periodontal diseases in adults 50+ years were studied in a longitudinal study by Locker & Leake

(1993). More than 3000 subjects from Ontario were included for a telephone interview, and a subsample of $n = 907$ were invited to a dental control. The only variable that survived multivariate analysis in all samples was smoking. Education had an OR of 0.5 and was the only socio-economic variable that was significant.

In a study of employees at one paper mill in Finland, Markkanen et al. (1980) included education and income in the analysis of associations to periodontal diseases. Education explained only 0.9% of the variance in periodontal status, and the influence of income was never significant. Smoking was not included in the analysis.

As part of the Mini Finland Health Survey, 8000 inhabitants were invited to a dental examination. Markkanen et al. (1983) found a minor (1.7%) but significant association of education with periodontal diseases. Income was never significant in the multiple regression analysis. However, smoking was not included in the analysis.

As part of a national survey, questions were asked concerning quality of life as related to oral health. No dental examination was undertaken in this study by McGrath & Bedi (2002). Social class was significantly associated with the quality of life of oral health. People from lower social class backgrounds more frequently perceived oral health as being not important to life quality compared with those from higher social class backgrounds. Smoking was not included in the analysis.

The results of two cross-sectional studies were included in this descriptive presentation by Micheelis & Bauch (1996). One study from former East Germany (1989) and one from former West Germany (1992) were included. Socio-economic status was identified as being significantly associated with periodontal diseases. However, smoking was not included in the analysis.

A cohort of individuals who developed DM Type 1 (DM1) before the age of 17 were interviewed and had a dental control 32 years (on average) after the onset of DM1. Included socio-economic variables were education and income. Moore et al. (1999) found that age >32 years (OR 3.0), more than 8.2 years of DM1 (OR 3.3) and especially smoking (OR 9.7) were associated with periodontal diseases. None of the socio-economic variables entered the multivariate equation.

A cross-sectional study, including oral examinations and interviews, was undertaken in Tanzania by Mumghamba et al. (1995). A possible design problem of the study concerns the traditional use of ''mswaki'', i.e. chewing of sticks for cleaning the teeth. Only rural living had a significant OR (3.5) for periodontal pockets. Smoking was not included in the analysis.

A screening programme of oral health status was based on oral inspection conducted by a dental hygienist using a mirror and explorer. The population consisted of members of a pre-paid medical group plan, i.e. selected patients. The research question concerned the relation between socioeconomic variables and periodontal status. Nikias et al. (1977) found that level of education was associated with periodontal problems, but that economic status was related to restored teeth. Smoking was not included as a variable.

In a cross-sectional study including 552 patients at a dental school, dental examination and radiographic verification were undertaken, including an inquiry to identify risk factors of severe periodontal diseases in Swedish adults. Norderyd (1998) found that smoking >10 cigarettes a day had the highest OR, 11.8, and that neither income nor education was significantly associated with periodontal diseases.

In a cross-sectional study including individuals aged 65+ years, Palmqvist (1986) included willingness to pay as a variable supposedly correlated to periodontal diseases. The dropout rate was more than 2/3; thus, the remaining sub sample can hardly be representative of the random population sample. No socio-economic variable was significantly correlated to periodontal diseases.

From an earlier published cross-sectional study on smoking and periodontal diseases, Paulander et al. (2003) carried out an analysis excluding smoking but including education as a variable. Education was significantly associated with probing attachment level for subjects <65 years of age. If age was also included in the multivariate analysis, no significance remained, however.

A study by Persson et al. (1998) on oral health included only low-income older persons. Smoking was associated with probing depths. Another result was that women on hormone replacement therapy had lower frequencies of probing depths >5 mm. None of the socio-economic variables, education and income, were significant.

Levels of education, as correlated to the frequency of periodontal diseases, were studied by Plasschaert et al. (1978). The study showed that education was correlated to periodontal diseases. Smoking was not included in the analysis.

In a survey undertaken in some urban and rural parts of Delhi, Shah (2003) investigated gender differences and oral health. Socio-economic status was defined from the Rup-Nagpal's scale (WHO). There were significant socio-economic differences between men and women, but not as regards periodontal health. The distribution of men *versus* women of the study, compared with the Indian population, was very skewed.

Subjects recruited from a dental centre in Taiwan were interviewed and had a dental control for a study of lifestyle and psychosocial factors associated with chronic periodontal diseases. Teng et al. (2003) could explain 36% of chronic periodontal diseases attributable to smoking, toothbrushing frequency and psychosocial stress. None of the included socio-economic variables was significant.

Based on the results of the 1993 Adult Health Survey, Treasure et al. (2001) presented multivariate analyses concerning periodontal diseases defined as PAL >4 mm. Age was the factor most strongly associated with periodontal conditions. Males, and education below degree level, were also significant. The authors regretted that smoking was not a variable included in the national survey.

In a cross-sectional study from Finland, based on data from the 1980s, Turunen et al. (1993) focused on determinants of poor dental health. Of the defined socio-economic variables, gender, marital status and vocational education were significantly associated with high intensity of oral disease. However, smoking was not included as a variable in the analysis of determinants of poor dental health.

In a large Swedish survey ($n = 6343$) combined with dental control of a subset (20%) of the participants, Unell et al. (2000) studied clinical and subjective indicators of periodontal diseases in subjects 50 years of age. Dental services utilization, dental attitudes and smoking were significantly associated with periodontal diseases. However, no socio-economic variable was significant.

Structuring of the included studies

Of all included 47 studies, there were 34 showing a significant association between socio-economic factors and periodontal disease, thus roughly 3/4 of all studies. However, focusing on the study design, which may be crucial for showing causality and inclusion of the variable smoking, a four-field table was made (Table 2) that reveals possible explanations other than those described above (''Description of the studies'').

A cross-sectional study design, smoking as a factor included as a variable (Table 2)

When smoking was included as a variable, 11 out of 16 studies, about 70%, stated a significant association between socio-economic variables and periodontal diseases.

Table 2. Socio-economic variables studied: significantly associated with periodontal disease, or not, and reference (first author's name, year of publication)

Study design	
cross-sectional, survey	case–control, longitudinal
Smoking included	
Socio-economic variable(s) significant	Socio-economic variable(s) significant
BMI (Al-Zahrani 2003)	Education <12 years (Beck 1997)
Race (Borell 2002)	Education, whites, >12 years (Brown et al. 1994) Education <12 years (Elter et al. 1999) Education (Hansen et al. 1995)
Income, education (Bridges et al. 1996)	
Higher social class (Bullock et al. 2001)	
Race, economic status (Craig et al. 2001)	
Education, residence, socio-economic index (Drake et al. 1991)	
Education, residence, income (Dolan et al. 1997)	
Race, education (Dye & Vargas 2002)	
Education (Hujoel et al. 2003)	
Below poverty status (Ismail et al. 1987)	
Education, residence (Mumghamba et al. 1995)	
No significance	No significance
Income, education (Borrel et al. 2003)	Education, household income Locker & Leake (1993)
Education, income, socio-economic status (Grossi et al. 1994)	Education, income (Moore et al. 1999)
Income, education (Norderyd 1998)	Income, education (Persson et al. 1998)
Income, willingness to pay (Palmqvist 1986)	Income, education, occupation (Teng et al. 2003)
Education, working hours (Unell et al. 2000)	
Smoking NOT included	
Socio-economic variable(s) significant	Socio-economic variable(s) significant
Education, manual work (Bergman et al. 1991)	Education, socio-economic group (Halling & Bengtsson 1984)
Socio-economic level (Bourgeois et al. 1999)	
Income (Brodeur et al. 2001)	
Socio-economic level (Drury et al. 1999)	
Socio-economic status, education (Gamonal et al. 1998)	
Race, income, education (Gugushe 1998)	
Socio-economic status (Hobdell et al. 2003)	
Education (Horton & Sumnicht 1968)	
Income, education (Lang et al. 1994)	
Social class (McGrath et al. 2002)	
Socio-economic status (Micheelis & Bauch 1996)	
Education, income (Markkanen et al. 1980)	
Education, income (Markkanen et al. 1983)	
Education (Nikias et al. 1977)	
Education <65 years of age (Paulander et al. 2003)	
Education (Plasschaert et al. 1978)	
Education, income (Turunen et al. 1993)	
Education (Treasure et al. 2001)	
No significance	No significance
Socio-economic class (Grbic et al. 1991)	Socio-economic classes I–III, gender (Demetriou et al.1995)
Socio-economic class (Shah 2003)	Education, occupation, income, employment (Gelskey et al. 1998)

BMI, body mass index.

A cross-sectional study design, without smoking included as a variable (Table 2)

Eighteen out of 20 studies, 90%, stated that socio-economic variables were significantly associated with periodontal diseases. Only a small study ($n = 75$) of patients at a dental school (Grbic et al. 1991) and a large study from India (Shah 2003) showed no significance.

Longitudinal studies or case–control studies, smoking as a factor included as a variable (Table 2)

Of the eight included studies, there were four studies in favour of an association between socio-economic factors and periodontal diseases and another four studies that found no significant association. Concerning two of the studies in favour of an association, the study by Brown et al. (1994) was a rather short longitudinal study (18 months). The study by Elter had a dropout rate of about 3/4 after 7 year's follow-up (Elter et al. 1999). One of the studies that found no significant association included only patients with DM for more than 32 years.

Also, in this field of Table 2 the result turned out to be conflicting, four studies found a significant association and four studies did not.

Longitudinal studies or case–control studies, smoking not included as a variable (Table 2)

There are two studies, one Swedish study, including 1462 women, that found a significant association between periodontal diseases and education, as well as for socio-economic group (Halling & Bengtsson 1984). A more recent (1998) retrospective case–control study (205+205 individuals) from Canada found no such significance for the included variables education, occupation, income and employment. However, being single had an OR of 1.77 (Gelskey et al. 1998).

Thus, in this field of Table 2, a conflicting result regarding the association between socio-economic variables and periodontal diseases can be observed.

Discussion

By classifying the studies according to study design, it becomes evident that the

association often claimed between socio-economic status and periodontal diseases to a certain extent probably was because of the study design chosen. This can be described by the fact that 29 out of 36 studies with a cross-sectional design were in favour of the association. Considering the studies with a longitudinal or case–control design, there were five in favour of the association, but also against, thus giving a conflicting result.

In studies using a cross-sectional design, the historic health-related behaviour (smoking, dietary intake and oral hygiene practice) may be different in various age cohorts. It should also be noted that different populations are seen and different measurement scales may be used to assess periodontal diseases (for example in NHANES 1 *versus* NHANES 3). In longitudinal studies, the loss of teeth during the study period may be one factor leading to the underestimation of periodontitis.

It was suggested that inequalities in health evolve because lower social groups have adopted more dangerous and health-damaging behaviour and may have less interest in protecting their health for the future. Excessive consumption of harmful commodities, certain foods, tobacco and alcohol and underutilization of preventive health care is implied to be harmful. It has been proposed that the distinct pattern of behaviour, knowledge and health attitudes within certain social groups is mainly related to educational level (Peterson 1990). Smoking is an evident risk factor for periodontal diseases. However, it is a fact that people with lower education, compared with those with higher education, have a higher smoking frequency (Tillgren et al 1996). Thus, it is likely that smoking is a confounding variable to socio-economic variables in studies where smoking as a factor was not included. In a prospective study over 10 years, the effect of educational level on periodontal disease progression was found to be significant in never smokers (Paulander et al 2004). In studies where the smoking factor has not been analysed, the effect of socio-economic factors on periodontal diseases could be masked.

Conclusions

Based on relevant study designs, and including smoking factors in the analysis, the socio-economic variables associated with periodontal diseases appear to be of less importance than smoking.

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