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Socioeconomic position during life and **periodontitis** in adulthood: a systematic review

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Abstract

Background: Socioeconomic position (SEP) is a well-known risk indicator for chronic periodontitis. However, it is still unclear how SEP during the life course influences periodontal outcomes in adulthood. **Aims:** To systematically review longitudinal studies investigating the influence of individual-level SEP during the life course on subsequent periodontitis in adulthood. **Methods:** Inclusion criteria were epidemiological longitudinal observational studies, in which indicators of relative SEP were assessed prior to clinical assessment of periodontitis. Six electronic databases (PubMed, EMBASE, Web of Science, Scopus, LILACS and ScieLO) were searched. The methodological quality of the studies was assessed using the Newcastle–Ottawa Quality Assessment Scale (NOS). **Results:** The search identified 1,720 papers. After removal of duplicates (n=697), title and abstract screening (n=996), and full-text review (n=19), eight original manuscripts from seven studies were finally included. Sample sizes ranged from 167 to 2806, and the follow-up time from exposure to outcome ranged from 2 to 28 years. Studies evaluated education, occupation or income as SEP indicators. Prevalence, extent and severity of periodontal attachment loss, probing pocket depth and alveolar bone loss were the studied outcomes. Based on NOS, studies presented low risk of bias. Six out of eight papers reported that relatively low SEP earlier in life was associated with poorer periodontal health in adulthood. **Conclusions:** The available scientific evidence

demonstrates potential longitudinal impact of earlier lower SEP on later periodontal health. The findings were consistent despite differences in study methods.

Introduction

Severe periodontitis was ranked as the 6th most prevalent condition within the Global Burden of Disease 2010 Study, with an estimated prevalence of 10.8%. Well-recognized risk factors for periodontitis include smoking, poorly-controlled diabetes and some periodontopathogens². Moreover, lower socioeconomic position (SEP) is a well-identified risk indicator for periodontitis^{3,4}, at both contextual⁵ and individual levels⁶.

Evidence suggests that SEP earlier in life negatively impacts on the incidence of chronic diseases such as respiratory and cardiovascular diseases (CVD)^{7,8}. These chronic diseases share several risk indicators with periodontitis, especially health-related behaviours, such as tobacco use⁹, excessive alcohol consumption¹⁰, unhealthy diet and lack of physical activity¹¹. Therefore, it is plausible that the pathways linking SEP and general health could also be applied to oral health. Several potential explanations for the life course effects of SEP on periodontitis are hypothesized including both behavioural and biological pathways¹². However, a significant gap persists in understanding the role of SEP in the onset and progression of periodontitis.

Studies on the associations between SEP and periodontitis have most commonly investigated the role of education, occupation, income, wealth and place of residence, as indicators of SEP^{5,13-15}. These studies consistently report social gradients between SEP and periodontal health: the higher the relative SEP, the better the health¹⁶. Consistently, the literature clearly indicates that SEP is an important risk indicator for periodontitis.

Three systematic reviews have assessed the association between SEP and periodontitis and discussed possible causal relationships¹⁷⁻¹⁹. Although causality criteria proposed by Bradford Hill²⁰ have important limitations²¹, it remains in popular usage among most health scientists²². Among these criteria, previous systematic reviews have provided evidence for strength of association, consistency of association and dose response

relationship. However, as these systematic reviews mostly reported findings from cross-sectional studies, they cannot provide evidence from a longitudinal perspective. Therefore, evidence related to the temporal relationship is key to fill the current gap in causal inference.

Consequently, this study aimed to systematically review longitudinal studies that investigated influence of individual level SEP during the life on subsequent periodontitis in adulthood.

Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement and the Cochrane Handbook^{23,24}. The review question that guided this systematic review was: “Does SEP earlier in life influence periodontal status in adulthood?”

Potentially eligible papers comprised of all epidemiological observational longitudinal studies that included clinically assessed indicators of periodontitis as outcomes and measured indicators of relative individual level SEP. Both prospective and retrospective longitudinal studies were considered eligible for inclusion. This review considered studies that clinically assessed periodontitis in adulthood, including at least one of the following measures: clinical attachment loss, periodontal pocket deep and alveolar bone loss, irrespective of periodontitis case definitions. Studies that used only self-reported measures of periodontitis were excluded. The exposure (SEP) should have been collected at least once prior to the outcome by means of education, income and/or occupation. The search did not have any language restriction. Publication date was not considered as a reason for papers’ exclusion in this review.

The search was performed in six electronic databases (PubMed, EMBASE, Web of Science, Scopus, LILACS (Latin American and Caribbean Health Sciences Literature) and ScieLO (Scientific Electronic Library Online) until 17th December 2015.

Additionally, aiming to search for potentially unidentified publications, hand searches were conducted on the reference lists of papers included in the systematic review. A standard letter seeking new relevant data was also sent to the authors of the included studies to capture any unpublished data.

Search strategy for each database can be found in the Supplementary Material section (A).

Step 1: Electronic searches were performed by the first author.

Step 2: Results from the 6 databases were combined using the EndNote(x6) software, and duplicate references were identified and removed.

Step 3: Titles and abstracts were first screened independently by 2 authors (H.S.S. and A.S.). If the necessary information for inclusion or exclusion of the article was unavailable in the title and/or abstract, the full text of the report was read. In case of disagreements regarding eligibility, the two reviewers attempted to reach a consensus through discussions. Persistent disagreements were resolved by the third reviewer (L.G.D.).

Step 4: Full-texts of the selected abstracts in Step 3 were retrieved. The authors were contacted if the document was not available online. The papers were read by two reviewers, checking whether they matched the inclusion criteria for this systematic review. In case of exclusion after full text review, the reasons were recorded by the reviewers (Table S1).

Step 5: Data extraction from the included papers was performed independently by the two reviewers.

Data collection process

The selected papers underwent data extraction using a pre-tested spreadsheet. Data from multiple reports of the same study were identified in order to avoid duplication. Data regarding study identification and characteristics were defined by author and journal information, participants' characteristics, location and recruitment method. Detailed information on the exposure and the outcome were also recorded. The findings of each study were collected as stated within the paper, along with the information on covariates, confounding factors and effect modifiers. Finally, the study limitations and the key conclusions of studies were collected verbatim.

The methodological quality assessment of the selected studies was performed independently by two reviewers (H.S.S. and A.S.) using the Newcastle–Ottawa Quality Assessment Scale (NOS) for cohort studies²⁵. The assessment of bias included criteria on Selection, Comparability and Outcome features. A study was awarded a maximum of one point for each item within the Selection and Outcome categories (totalizing a maximum of four and three points in each category, respectively)²⁶. A maximum of two points were given for Comparability item. Disagreements were resolved through discussion.

Results

The combined search across the six databases identified 1,720 studies. After duplicate removal, screening of titles and abstracts, and full text examinations, eight original papers involving seven primary studies were included in this review and underwent data extraction. The stepwise process of study selection is summarized in Figure 1.

The characteristics of the selected studies are described in Table 1. Five out of the eight selected studies were from high income countries (one each from Pomerania, Sweden, New Zealand and two from USA), compared to two from middle/low income countries (Brazil and China). The combined sample size of this systematic review was 6363, and sample sizes of the individual studies ranged from 167 to 2806. The follow-up time varied from 2 to 28 years, with the majority between 5 and 11 years.

Details of the socioeconomic indicators adopted by each study and the periodontitis case definitions are presented in Table 2. Education as the sole measure of SEP was adopted by one paper²⁷ and occupation by another two papers, both from the same cohort study^{28,29}. Four studies used both education and household income^{16, 30-32}, and one study defined SEP by combining information about family income and individual educational level³³. Measures of periodontitis varied considerably among the studies. The assessed outcomes included periodontal attachment loss, probing pocket depth and alveolar bone loss. One study assessed periodontal health status by using the Community Periodontal Index (CPI)³², which is a measure including gingival bleeding, dental calculus and periodontal pockets³⁴.

Table 3 summarizes the findings of the selected studies on SEP and periodontal outcomes. Two papers reported Odds Ratios^{28,30}, three reported β coefficient^{16, 31, 32}, one reported Relative Risk²⁷, one showed the mean annual proximal periodontal attachment loss (PAL) progression³³ and another reported crude associations between childhood SEP and trajectories of periodontitis²⁹. Due to the observed heterogeneity in the choice of exposure and outcome variables, and the summary measures between the included studies, a meta-analysis was not possible. Thus, a narrative synthesis was adopted for summarizing the findings, based on the guidelines by Mulrow et al³⁵.

Six of the eight selected studies reported that relatively lower SEP earlier in life was associated with poorer periodontal health. Significant associations between SEP and periodontitis were not reported in two studies, which did not account for potential confounding^{27,32}. Five of the eight papers assessed SEP during adulthood, before the outcome. Of the three papers that assessed SEP during childhood, one did not find a

significant association³². The other two papers were from the same study, and reported inverse associations between SEP and periodontitis^{28,29}. Half of the included studies reported unadjusted associations between SEP and periodontal outcomes. The four studies which reported adjusted estimates analysed the data using multivariable regression models^{16,27,28,31}.

The study conducted by Paulander and colleagues did not report a statistically significant association between SEP and periodontitis²⁷. However, after stratification by smoking status and adjustment for confounders, their analysis found an inverse association between education attainment and alveolar bone level loss among individuals who had never smoked.

According to NOS, most of the selected studies were considered to be of high quality, while only one study was of low methodological quality (Figure S1). Most studies failed to comply with the NOS criterion related to sample selection procedures.

Discussion

The findings of this systematic review showed that lower SEP during life increased the probability of future occurrence and progression of periodontitis, regardless of the SEP measure. These findings are in accordance with previous systematic reviews¹⁷⁻¹⁹. However, to the best of the authors' knowledge, this is the first systematic review using evidence entirely from longitudinal studies.

Some strengths of this systematic review should be emphasised. First, the search strategy was broadly developed. The electronic search was performed in six databases of interest in the dental field, and all the steps of this review were performed in duplicate, to avoid individual bias. Second, the quality assessment confirmed the high quality of the included studies, reinforcing the overall finding of the review. Finally, the included studies presented a broad range of socioeconomic measures as well as different assessment of periodontal outcomes, and our findings were consistent despite such variations.

However, this review is not free of limitations. There was considerable heterogeneity across studies included in this systematic review. For instance, the SEP indicators adopted by the studies included annual or monthly household income, parental or individual educational attainment and parental occupation. Additionally, some studies assessed SEP indicators in childhood. Periodontitis case definitions also varied considerably. Periodontitis was assessed using periodontal pocket depth, clinical attachment level and alveolar bone loss at a time

point or progression during the study periods. Analytical methods also varied, with some studies reporting crude associations between the exposure and outcome, and others reporting estimates adjusted for confounding factors. Despite these variations in measures of exposure, case definitions and methodological approaches, the studies consistently reported an inverse association between SEP earlier in life and periodontitis later in life. While it is acceptable to integrate heterogeneous studies in a systematic review, the conclusion should be inferred cautiously given the heterogeneities highlighted earlier in the body of evidence³⁵. Additionally, although systematic reviews with meta-analysis are able to provide a summary effect estimate of the included studies, if the primary studies are clinically, methodologically and/or statistically diverse, a pooled effect estimate can be misleading. Therefore, in this systematic review, lack of uniformity in exposure and outcome measures did not allow for a meta-analysis to be conducted.

The review also included studies that reported crude associations between SEP and periodontitis. As the relationship between SEP and chronic diseases is complex and mediators in this association are not well defined, adjusting for potential intermediary factors in a regression analysis can underestimate the association between SEP and periodontitis. Smoking is a potential intermediary factor for such a relationship. The literature clearly demonstrates the SEP gradient in tobacco smoking³⁶ and it is also well-known that smoking is strongly chained in the web of causation of periodontitis³⁷⁻³⁹. Therefore, it is critical to test the role of smoking as a mediator in the association between SEP and periodontitis. However, there appears to be a lack of tests accounting for the role of smoking in the relationship SEP-periodontitis in the primary studies included in this systematic review.

Two included studies reported non-significant associations between SEP indicators and periodontal measures^{27,32}. The assessment of periodontitis at a young age (18 years) might explain this inconsistent observation in one of the study, since periodontitis has a low prevalence among that age-group³². Additionally, this study assessed periodontal status using CPI, whose limitations in outcome detection is well-established^{40,41}. One study²⁷ observed that lower educational attainment at age 50 years was not associated with alveolar bone loss in a 10-year follow-up. However, a stratified analysis revealed that educational level had a significant effect on the 10-year alveolar bone level. The authors argued that in addition to the direct effect on periodontal health, smoking might be a marker for low SEP.

The literature points towards the need for a better understanding of potential causal pathways linking SEP and periodontitis¹². In this systematic review, only the study by Lu and colleagues³² aimed to test for mediation between SEP and periodontitis. The stated hypothesis was that socioeconomic childhood characteristics (parental educational attainment and household income) and oral health status in adulthood (dental caries experiences and periodontal health status) were mediated by the utilization of dental services during adolescence. Nevertheless, this hypothesis was rejected. Buchwald et al¹⁶ did not consider covariates, such as smoking status and levels of C-reactive protein as potential mediators between SEP and periodontitis relationship because the inclusion of such variables in their multivariable models did not attenuate the association between exposure and outcome. For instance, as smoking status was not associated with both the exposure and outcome, the authors decided not to include it as a potential mediator in the analysis. It should be highlighted that the authors' decision was purely statistically-driven, i.e., based on their dataset and not theoretically-driven or based on the scientific literature. None of the remaining studies assessed or discussed potential mediating pathways.

Socioeconomic position can be assessed by a range of measures. The studies included in this systematic review assessed the exposition by objective individual measures, namely household income, father's occupation and participant's or parent's education. Theoretically, there is not a best indicator of SEP⁶ and although many SEP indicators are partially correlated, distinct indicators have focused on different social dimensions. It is important to understand what each SEP indicator measures when assessing its influence on health, aiming to better understand the potential mechanisms of such influence. For example, measures of housing crowding and number of siblings may specifically reflect hygiene conditions and act as a marker for infectious disease risk⁶. The ideal SEP indicator varies according to the health condition and the moment of life it is being evaluated^{6,42}. It is appropriate to use different indicators of SEP, capturing a range of SEP dimensions. The diverse range of SEP indicators observed in the present study is substantiated in other systematic reviews assessing the association of SEP with general chronic health outcomes^{7,42}.

This systematic review contributed evidence that low SEP earlier in life may be a risk factor for periodontitis in adulthood. This finding can be explained as theoretically plausible in light of the current understanding of periodontitis and its pathological pathways. Individuals at relatively lower SEP may be at a higher risk of diseases, through stress-induced

ill-behaviours and physiological effects of chronic stress^{44,45}. The majority of studies included in this review did not evaluate SEP exposure during childhood, as only one of the included studies used a life course approach that accounted for SEP at childhood^{28,29}. According to the life course theories, childhood adverse socioeconomic background alters the host immunoinflammatory response¹¹. The hypothetical pathways for the effect of SEP on periodontitis are yet to be confirmed. The best way to test such theories is through prospectively designed studies that evaluate participants from childhood until the onset of periodontitis and beyond, given it is a chronic cumulative condition. This approach allows researchers to account for a range of variables over time that could confound the relationship, which may, in turn, introduce bias to the estimates. However, residual confounding may occur due to unmeasured/unadjusted variables, regardless of the study design.

The overall methodological quality of the selected articles in this review was considered high. However, the study by Machtei and colleagues had important methodological limitations³¹ such as the use of two different indicators of SEP without detailed explanation of how these indicators were measured and categorized. Although the study was well conducted, it did not report important characteristics, such as the representativeness of the sample. Half of the included studies achieved the highest score in the NOS (Table S2). But, none of the included studies approached the data using specific longitudinal data analysis procedures. Longitudinal studies following an appropriate analytical plan and using measures of incidence of periodontitis still need to be conducted.

Conclusion

Our systematic review showed that individuals who were exposed to relative lower socioeconomic conditions earlier in life presented worse periodontal outcomes in adulthood. This finding was consistent across the broad range of SEP indicators and measures of disease adopted in the primary studies. This finding provided evidence for a temporal relationship, a requisite to confirm causal nature of the association between SEP and periodontitis. The review also indicated a need for prospective analytical cohort studies with long-term follow-up testing multiple life course theories to determine the role SEP during different life periods has on periodontitis in adulthood. It is paramount to understand such a relationship to orientate public policy strategies, aiming to focus the effort on the population at highest risk, implementing such strategies which may then reduce social inequalities in periodontal outcomes.

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438 Figure 1. Flowchart of studies selection for the systematic review

439 Table 1. Main characteristics of the included papers

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First author/Year	Country	Journal	Sampling characteristics	n (followed up)	Time frame (from exposure to follow-up)
Buchwald, 2013	Pomerania	J Clin Periodontol	20- to 79-year-old in the north-east of Germany	2806	5 years
Haas, 2012	Brazil	J Clin Periodontol	14–103 years (baseline) from Porto Alegre, Brazil	697	5 years
Ismail, 1990	USA	J Dent Res	Non-institutionalized individuals, five years of age or older at baseline, residing within an 80-km radius of Tecumseh (Michigan, US).	167	28 years
Lu, 2011	China	Community Dent Oral Epidemiol	Follow-up of children who had participated in the Hong Kong Oral Health Survey in 2001 (18 years old during follow-up)	221	6 years
Machtei, 1999	USA	J Clin Periodontol	Age range: 25–75 years at baseline	415	2 to 4 years
Paulander, 2004	Sweden	J Clin Periodontol	60 years old, living in the County of Varmland, Sweden	295	10 years
Poulton, 2002	New Zealand	The Lancet	Birth to 26 years	931	11 years
Thomson, 2013	New Zealand	J Clin Periodontol	Birth to 38 years old during the last evaluation	831	23 years

Table 2. Descriptive information on socioeconomic position and periodontal outcome in the selected papers

Socioeconomic exposure			Periodontal outcomes			
First author/Year	Type of exposure	Exposure details	Primary outcome	Case definition	Summary association measures	Comment
Buchwald, 2013	Education and income	Education: according to the final school grade; Income: monthly household income	Clinical Attachment Loss (CAL)	distance between the cement-enamel junction (CEJ) and the pocket base rounded to whole millimetres	β -coefficients	Worked with disease progression
Haas, 2012	Socioeconomic position	SEP defined by combining information about family income and individual's educational level	Periodontal attachment loss (PAL)	the distance from the CEJ to the bottom of the pocket/sulcus	Mean annual proximal PAL progression (mm) for all sites	Worked with disease progression
Ismail, 1990	Education and income	Not described	Pocket depth and periodontal attachment level	Those with a mean loss of periodontal attachment (LPA) difference of less than 2 mm over the 28 years were classified as "low LPA", while those with a mean LPA difference of 2 mm or more were classified as the "high-LPA" group.	Odds Ratios	Worked with disease progression (low and high LPA differences between the followup and baseline examinations)
Lu, 2011	Education and income	Education: Parent's educational attainment; Income: monthly household income	Periodontal health status was assessed by the Community Periodontal Index (CPI)	Highest Community Periodontal Index score	β -coefficients	
Machtei, 1999	Education and income	Education: High School/College; Income: Maximum annual household income	Probing pocket depth (PPD)	The distance from the free gingival margin (FGM) to the clinical base of the pocket in a line parallel to the long axis of the tooth using a Florida Probe System (FPS) with a 10 mm pocket probe	Coefficient/Correlation	The regression assessed annual change in pocket depth
Paulander, 2004	Education	Educational level: (i) low educated individuals (only compulsory school training), or (ii) high educated individuals	Alveolar bone loss	Not well defined	Relative Risk (RR)	Worked with Relative Risk (RR) for a mean 10-year ABL loss

(more than compulsory school training).

Poulton, 2002	Occupation	Childhood socioeconomic status is the average of the highest socioeconomic status level of either parent, assessed repeatedly at the study member's birth and at ages 3, 5, 7, 8, 11, 13 and 15 years.	Periodontal disease	Periodontal disease was judged present if there was more than 4 mm loss of periodontal attachment for at least one site.	Odds Ratios	Presented only adjusted OR
Thomson, 2013	Occupation	Childhood socioeconomic status is the average of the highest socioeconomic status level of either parent, assessed repeatedly at the study member's birth and at ages 3, 5, 7, 8, 11, 13 and 15 years.	Changes in the occurrence of periodontal attachment loss (AL)	The CAL for each site was computed by summing the GR* and PD# measurements. The changes in CAL between 26 and 32 (and between 32 and 38) were determined for each site by subtracting the later age's CAL from that of the earlier one.	Crude association between childhood SES and trajectories of periodontal disease up to age 38 years.	Same study of Poulton 2002; Worked with periodontal disease trajectory

Table 3. Summary of the findings of the included papers

First author/Year	Main findings
Buchwald, 2013	Low education and low income level were associated with progression of mean clinical attachment level ($p < 0.010$ and $p = 0.046$ respectively).
Haas, 2012	Subjects of low SES showed higher rates of disease progression than subjects of high SES respectively.
Ismail, 1990	On the basis of bivariate analyses, the individuals with high LPA increase presented lower education level comparing to those with low LPA increase.

Lu, 2011 Both the household income level and parental education level for children aged 12 years had no significant effects on highest CPI score at ages 15 and 18 years old ($P > 0.05$).

Machtei, 1999 In the stepwise multiple regression analysis, income was predictive of annual change in pocket depth after controlling for baseline probing pocket depth, smoking, thyroid disorder and presence of *Capnocytophaga* species.

Paulander, 2004 In a model considering all the sample, educational level was not associated with bone loss. However, a predictive model including only subjects who had never been smokers revealed that educational level had a statistically significant influence on the 10-year ABL change.

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Poulton, 2002 All dental health measures at age 26 years showed a graded relation with childhood SES. As SES increased, the proportion of individuals with periodontal disease decreased.

Thomson, 2013 On the basis of bivariate analysis, individuals from the lower childhood SES had a higher prevalence of periodontal experience.

SES: Socioeconomic status; LPA: Loss of periodontal attachment; CPI: Community Periodontal Index; ABL: Alveolar bone loss.

Figure caption:

Figure 1. Flowchart of studies selection for the systematic review

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Author/s:

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Title:

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