

Adolescents' sense of coherence and smoking as longitudinal predictors of self-reported gingivitis

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Abstract

Objective: This study sought to determine the influence of sense of coherence (SOC), a personal stress-coping resource, and smoking on the self-reported gingival health of a cohort of rural black South African adolescents.

Methods: This 18-month study involved a three-wave survey of a representative sample of eighth graders from 11 randomly selected high schools in the Limpopo province, South Africa ($n=970$). Using a generalized estimating equation model, we examined the correlates of recent gingivitis, defined as self-reporting frequent gingival bleeding (GB). Explanatory variables included baseline socio-economic status, age, gender, plaque levels, toothbrushing frequency, tobacco use status and SOC levels.

Results: Among our sample, 74.6% reported experiencing gingivitis at some point during follow-up, while 41.9% reported frequent GB at the last survey. Factors that were positively associated with recent gingivitis include living in poor households [odds ratio (OR)=1.49; $p<0.01$], having higher plaque levels (OR=1.18; $p=0.04$) and smoking regularly (OR=1.57; $p=0.04$). Self-reporting gingivitis was negatively associated with being female (OR=0.76; $p=0.02$) and having a higher SOC (OR=0.96; $p<0.001$).

Conclusions: Adolescent smoking and SOC levels are independent predictors of self-reported gingivitis. Therefore, in addition to plaque control, smoking prevention and the teaching of stress-coping skills may be important interventions for promoting adolescents' gingival health.

Article Text

Experiencing "bleeding gums" when brushing one's teeth is the most common symptom of plaque-induced gingivitis. Self-reported gingival bleeding has been shown to be a good measure of service demand for periodontal care (Rayant & Sheiham 1980) and it has been suggested as a useful measure for monitoring gingival health among adolescents in developing countries where the costs of clinical oral surveys may be prohibitive (Taani & Alhaija 2003). A previous adolescent study finding suggests that self-reported gingival bleeding may be explained by the same factors that are associated with clinical gingival health status (Kallio & Murtomaa 1997). Periodontal disease, including gingivitis, is a multifactorial condition. Bacterial plaque is the principal aetiological factor and several other local and systemic factors have a modifying role in its pathogenesis (Albandar 2002).

For instance, several studies have demonstrated that inflammatory response of the gingiva to a given amount of supragingival plaque appeared to be altered or depressed in smokers compared with the gingiva of non-smokers (Bergström & Preber 1986, Calsina et al. 2002). This suppressive effect of smoking on the inflammatory response of the gingiva has been suggested to be dependent on the intensity of smoking (Dietrich et al. 2004). However, very few of these studies have been conducted among adolescents who commonly display a lower smoking intensity than adults. The few studies of the effect of smoking on gingival health that have been done on adolescents, mainly in developed countries, have produced inconsistent results (Modeer et al. 1980, Romao & Wennström 2007).

Furthermore, most of the existing studies on the effect of smoking on gingival health have either been limited to cross-sectional designs, or have employed analytical methods that do not adequately model highly correlated data such as repeated measurements of gingival health of the same subjects over time. A recent study using a modelling method which does adequately model correlated data suggests that some subjects tend to have gingiva that consistently bleed after mechanical manipulation while others' gingiva do not (Müller & Stadermann 2006). Although these authors provided no direct evidence, these authors suggested that their observation of a greater significant serial correlation of gingival bleeding at subject level (compared to that at tooth level) might be related to differences in coping with stress.

There is indeed growing evidence that stress directly influences periodontal disease occurrence (Deinzer et al. 1999, Klages et al. 2005). Inadequate coping with stress may also be associated with irregular toothbrushing and thus with inadequate plaque control (Deinzer et al. 2005). Inadequate stress-coping behaviour has, in fact, been directly associated with periodontal disease (Genco et al. 1999, Wimmer et al. 2002). These

observations have drawn public oral health researchers' interest to an increasingly popular psychological construct – Antonovsky's theory of Sense of Coherence (SOC) that seeks to explain the relationship between coping with life stresses and maintaining health (salutogenesis) (Antonovsky 1993, Watt 2002).

The higher a person's SOC is, the better he/she is able to cope adequately – he/she is able to find appropriate solutions in the face of challenges (mastery orientation) and stay healthy. Unlike other similar measures of personal resources for coping, such as emotional intelligence or resilience, SOC has been argued to be cross-culturally applicable because it does not measure specific coping mechanisms but a general disposition to coping with stress (Antonovsky 1993). SOC has been associated with health outcomes (Eriksson & Lindström 2006) and has recently received significant empirical research support as a determinant of toothbrushing behaviour in adults (Savolainen et al. 2005) and adolescents (Ayo-Yusuf et al. in press). Given that stress (Byrne et al. 1995) and low SOC (Glanz et al. 2005, Wainwright et al. 2007) have also been associated with smoking among adolescents and adults, the effect of smoking on gingival health may be confounded by stress or the ability to cope with stress.

In short, there is limited information available on the independent roles of stress coping and smoking on gingival health, particularly among adolescents in low-resource settings. Hence, the present study sought to determine the roles of SOC or the ability to cope with stress and smoking in predicting self-reported gingival health in a population of rural South African adolescents.

Methods

Study population and sample design

This longitudinal study was conducted in the rural Limpopo province of South Africa between April 2005 and October 2006. The participants in this study were eighth graders from 11 randomly selected public high schools. A two-stage sampling technique was used to produce a provincially representative sample of eighth graders. The first stage of the sampling consisted of a random selection of 11 of the 31 school districts in the Limpopo Province. School districts were selected with a probability proportional to the number of schools in the district. The second stage consisted of a random selection of one school from the cluster of high schools in each selected school district. All the eighth graders in the selected schools were eligible to participate in the study.

Calculations indicated that a sample of 894 adolescents would be necessary to explore the association between self-reported gingivitis and smoking. These calculations used the following parameters: 80% power, a 5% significance level, a ratio of unexposed subjects (non-smokers) to exposed subjects (smokers) of 6:1, an odds ratio (OR) to be detected of 2, an excess due to multivariate analysis of 15%, an excess due to non-response or missing data of 20% and a design effect of 1.1. Although we had determined that subjects from 10 schools would be needed based on the information that there were about 100

eighth graders per school, we actually contacted 11 schools, in case a school declined participation.

Participation in the study required informed consent from the school principal, the participants and their parents. After providing informed consent, the participants completed a pre-tested self-administered questionnaire during class time at baseline (T1), after 12 months (T2) and again after 18 months (T3). Following the questionnaire administration, a systematic oral examination was carried out on all consenting participants at baseline. Each participant was then provided with a toothbrush and toothpaste after his/her oral examination. The study protocol was approved by the University of Pretoria's Ethics Committee (22/2005).

Measures and definitions

Socio-demographic features

The study participants provided information about their age, gender, ethnicity (black African and others), estimated household income and the type of dwelling they lived in (formal housing – a brick house/flat; or informal housing – huts/tents or a non-brick house). The type of dwelling the subjects lived in (Wichmann et al. 2008) and the subjective measure of household income indicated served as two proxy measures for the socio-economic status of the participating adolescents. Because some adolescents may not be able to state their households' total earnings accurately, consistent with the protocol used in similar adolescent study (López et al. 2006), the respondents were instructed to choose from a range of options of what they estimated their households' total monthly earnings to be. On the basis of data from the report on income poverty that was derived from an analysis of the 2005 South African general household survey findings (Leatte 2006), we categorized the respondents into those that lived in "poor" households, that is, the subjects selected estimated monthly earnings between 0 (no income) and R1500, and those that did not live in "poor" households.

The current study was limited to those who identified themselves as black Africans ($n=970$; 95% of the total sample). This, therefore, imposed an inherent control for potential genetic variations that have been noted as potential modifying factors for the development of periodontal disease (Kornman & Di Giovine 1998, Albandar 2002).

Tobacco use status

Using items previously employed in national and international youth tobacco surveys (Swart et al. 2004), the respondents themselves were categorized as regular smokers if they indicated that they had smoked at least one cigarette (even a puff) within the 24 h preceding the survey and if they had also indicated smoking in the last week and in the last 30 days preceding the date of the survey. A similar approach was used to define regular oral smokeless tobacco/snuff users but in that case the question enquired whether the respondents had used snuff at least once within the referenced periods.

SOC

The original 13-item short version of Antonovsky's seven-point Likert-type SOC scale was included in the original questionnaire (Freire et al. 2001). However, the results of factor analysis reported in a previous paper have shown that six items of the original SOC scale were an internally consistent (Cronbach alpha=0.63) measure of SOC in the current adolescent population sample (Ayo-Yusuf et al. in press). Because this compared favourably with the Cronbach alpha (0.64) reported for a 17-item scale (factor-analysed from the original 29-item version of the SOC scale) used in another study of adolescents (Antonovsky & Sagy 1986), the six-item SOC scale was used in the current study (score range 0–42).

Toothbrushing frequency

To measure brushing frequency, respondents were asked the following question: "In the past month (30 days), how often have you been brushing/cleaning your teeth?" Guided by the findings from the pilot test, the response options provided were as follows: (1) "I did not always clean daily"; (2) "Always once daily"; (3) "Most days once, but some days twice daily"; (4) "Most days twice, but sometimes once" and (5) "Always brush at least twice daily". Respondents who indicated always brushing at least twice were classified as having "twice-a-day" or regular brushing behaviour (Ayo-Yusuf et al. in press).

Self-reported gingival bleeding (gingivitis)

For this main outcome measure, respondents were asked how frequently they had experienced "bleeding gums" while brushing in the 3 months before the survey dates. Those who indicated that their gums "always" or "often" bled were categorized as having frequent gingival bleeding or gingivitis and those who reported that their gums "never" bled or "seldom" bled were categorized as not having gingivitis (Ayo-Yusuf et al. in press).

Oral hygiene status

An objective measure of plaque control using the patient hygiene performance (PHP) index, as previously described by Podshadley & Harley (1968) and Maraj & Kroon (2004), was used to document patient oral hygiene (the mean range was 0–5; a higher mean plaque score represented poorer oral hygiene). Because the frequency distribution of the plaque scores was compatible with a normal distribution, we did not transform the scores, so they were used as a continuous variable, as was also done in a previous study in South Africa (Maraj & Kroon 2004).

All six trained examiners who conducted the oral screening on consenting participants ($n=910$) at baseline were blinded to the completed questionnaires. The inter-examiner agreement on plaque scoring was considered good, with a κ coefficient ranging between 0.72 and 0.88. No repeat examinations were conducted, as this was not feasible, considering that the plaque deposit is likely to be altered with repeated tooth staining with the plaque-disclosing agents used as part of the measurement protocol.

Past dental visit

Based on a question on past dental visits, the sample was divided into two groups, namely those who self-reported that they had never visited a dentist before and those who had made at least one or more past dental visits.

Data analysis

All those who provided data on self-reported gingival health at baseline and consented to an oral examination were included in the analysis. The main outcome was a self-report of recent frequent gingival bleeding (Coded 1) compared with a report of no recent frequent gingival bleeding (Coded 0). Descriptive and multivariate analyses were conducted to assess the rates and correlates of reporting gingival bleeding at the last follow-up stage (T3). For bivariate analyses, the option "svy" for survey data in Stata (Stata Corporation, College Station, TX, USA) was used to account for the fact that the study participants were nested within schools (the primary sampling unit). The χ^2 -test and *t*-tests were used to compare the characteristics of the study cohort with those of dropouts. Dropouts were defined as learners with baseline data (T1), but no data at either of the follow-up stages (T2 or T3).

For the multivariate modelling, all the subjects for whom at least one set of follow-up measurements on gingival health was available were included in the analysis. The analysis included fitting generalized estimating equation (GEE) models with the "logit" link function for analysis of the correlated data, in order to determine factors associated with recent frequent gingival bleeding. This was done to take into account the fact that this repeated measure of gingival health was nested within the same subjects (random effect). Missing data was also addressed by means of the GEE-estimating mechanism, which uses all the available pairs method to estimate the missing data from dropouts or intermittent missings.

In the first step, we used the GEE univariate analysis to determine factors associated with recent frequent gingival bleeding. In order to adjust for potential confounding, all variables that were $p < 0.15$ in the GEE univariate analyses were entered in a multivariate logistic GEE model using a stepwise approach (Müller et al. 2002). This involved the inclusion of the socio-demographic variables in one block, followed by the sequential inclusion of toothbrushing frequency, plaque score, smoking status and SOC. This, therefore, allowed us to examine whether or not the effect of the preceding variables was mediated by the effect of the succeeding variables (Baron & Kenny 1986). Considering that age could be a potential confounder, and given the wide age range of the participants, the age of the participants at baseline were always used as a covariate in the multivariate analyses irrespective of the level of statistical significance reached. All group differences were considered significant whenever $p < 0.05$.

Results

Baseline characteristics of the study population and dropout analysis

The study participants were between 12 and 19 years old, with a mean (SD) age of 14.4 (SD 1.5) years. Only 22.9% of our study participants had ever visited a dental professional and 37.4% reported frequent gingival bleeding at the baseline time. Of the study participants, 7% could be categorized as habitual or regular smokers and 58.8% were in early adolescence stage (12–14 years old). Other characteristics of our study participants are as shown in Table 1. An analysis of those lost to follow-up (dropouts) showed that there were no significant differences between the baseline social or behavioural characteristics of the participants that provided at least one follow-up measurement and the characteristics of those who were lost to the follow-up (see Table 1).

Table 1. Characteristics of participants that provided follow-up data compared with those of dropouts

Baseline characteristics	Participants followed-up % (N=845)	Dropouts % (N=125)	p-value
Lives in informal housing structure	13.1 (n=109)	16.4 (n=30)	0.37
Lives in poor household	71.7 (n=599)	69.5 (n=82)	0.72
Female	52.8 (n=445)	52.4 (n=65)	0.93
Late adolescence (15–19 years)	41.2 (n=344)	44.3 (54)	0.57
Ever visited a dentist before	22.9 (n=191)	20.2 (n=25)	0.57
Brushes at least twice daily	26.8 (n=225)	28.5 (n=35)	0.79
Daily/regular smoker	7.0 (n=59)	5.8 (n=7)	0.70
Daily/regular oral snuff use	1.0 (n=8)	1.7 (n=2)	0.33*
Recent frequent gum bleeding	37.4 (n=313)	35.8 (n=44)	0.68
		Mean (SD)	
Total SOC-6 score (range 0–42)	26.3 (7.2)	25.3 (7.3)	0.17
Age (range 12–19 years)	14.4 (1.5)	14.7 (2.0)	0.09
Mean plaque score (range 0–5)	2.84 (0.70)	2.81 (0.66)	0.69

Totals (n) may be lower than expected because of missing data.

* Fisher's exact test as χ^2 was not valid because an expected cell count was <5. SOC, sense of coherence.

Longitudinal analysis

The total sample contributed to 2505 observations with a median number of three visits. A total of 845 (87.1%) participants completed at least two surveys. Among our sample of eligible adolescents, 41.9% reported experiencing gingivitis at the last survey, but 74.6% reported experiencing gingivitis at some point during the 18-month study. The prevalence of self-reported gingival bleeding was consistently higher among regular smokers than among non-smokers, but this difference in prevalence only became significant at T3 (see Fig. 1).

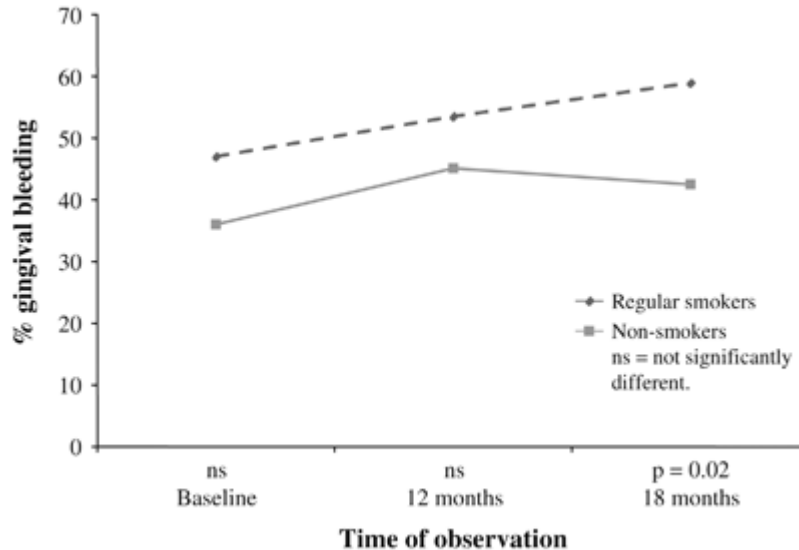


Fig. 1. Gingival bleeding by smoking status over time.

In univariate GEE, as compared to baseline, the odds of reporting gingival bleeding was higher at T2 (after 12 months) than at T3 (after 18 months), but this difference was attenuated in the final multivariate model after adjusting for potential confounders (see Table 2). Except for toothbrushing frequency, all the factors found to be significantly associated with reporting recent frequent gingival bleeding in univariate GEE remained independently associated with this outcome in multivariate GEE (see Table 2). The influence of twice-daily brushing lost statistical significance after we had controlled for mean plaque levels. However, the influence of the mean plaque score on recent frequent gingival bleeding only reached statistical significance after we had controlled for the SOC level. Furthermore, the influence of smoking on self-reported gingival health was slightly attenuated (but remained significant) after we had controlled for SOC level.

Table 2. Factors associated with recent self-reporting of recent frequent bleeding gums

Characteristics	Univariate GEE		Multivariate GEE*	
	OR (95% CI)	<i>p</i> -value	OR (95% CI)	<i>p</i> -value
Time				
Baseline <i>versus</i> 12 months	1.52 (1.24–1.88)	<0.001	1.49 (1.19–1.85)	<0.001
Baseline <i>versus</i> 18 months	1.40 (1.23–1.74)	<0.01	1.46 (1.17–1.83)	<0.01
Poor household resident				
Yes <i>versus</i> no	1.59 (1.26–2.02)	<0.001	1.49 (1.17–1.89)	<0.01
Gender				
Female <i>versus</i> male	0.79 (0.64–0.98)	0.03	0.76 (0.61–0.95)	0.02
Never visited a dentist before				
Yes <i>versus</i> no	0.99 (0.77–1.27)	0.91		
Brushes at least twice daily				
Yes <i>versus</i> no	0.78 (0.61–0.99)	0.04	0.79 (0.62–1.00)	0.06
Plaque score (per unit change)				
	1.15 (0.99–1.34)	0.08	1.18 (1.01–1.39)	0.04
Regular oral snuff user				
Yes <i>versus</i> no	1.68 (0.60–4.75)	0.32		
Regular smoker				
Yes <i>versus</i> no	1.74 (1.16–2.61)	0.01	1.57 (1.02–2.39)	0.04
SOC total score (per unit change)				
	0.96 (0.95–0.98)	<0.001	0.96 (0.95–0.98)	<0.001

Model included all study participants that provided complete data on all explanatory variables ($n=863$).

* In addition to the above variables, the multivariate models included age as covariates.

GEE, generalized estimating equation; OR, odds ratio; CI, confidence interval; SOC, sense of coherence.

In the final model, the factors that were positively associated with recent frequent gingival bleeding included living in a poor household (OR=1.49; $p<0.01$), increasing plaque levels (OR=1.18; $p=0.04$) and regular smoking (OR=1.57; $p=0.04$). Reporting recent frequent gingival bleeding was found to be negatively associated with being female (OR=0.76; $p=0.02$) and higher levels of SOC (OR=0.96; $p<0.001$).

Discussion

This study is the first study to examine the longitudinal course of self-reported gingival health among South African adolescents. In the present study, at some point during the 18-month study period, three-quarters of the study participants reported having experienced gingivitis. Recent frequent gingival bleeding was less likely to be reported among those with a higher SOC at the baseline time, but was more prevalent among those with poorer oral hygiene, those smoking regularly and those living in poor households. Our findings are consistent with previous studies as our findings also indicated that the adolescents that reported poor gingival health were less likely to be females (Albandar 2002) and more likely to be living in lower income households (Kallio & Murtomaa 1997, López et al. 2006). As expected, the influence of twice-daily brushing lost significance after we had controlled for plaque levels, thus confirming that the effect of regular brushing on reducing the likelihood of reporting gingivitis was perfectly mediated by the level of plaque control achieved. Also, consistent with recent literature (Müller & Stadermann 2006), a number of characteristics were found to be independently and positively associated with reporting recent frequent gingival bleeding in the current study, including higher plaque levels and regular smoking.

The difference between the findings of the current study and those of a recent study of Swedish adolescents (Romao & Wennström 2007) and previous studies on adults that failed to demonstrate a significant positive association between smoking and increased gingival bleeding may be related to the differences in the study design used and/or differences in the population studied. For instance, while this study showed that only about a quarter of the participating adolescents brushed twice daily, a previous study of a Swedish adolescent cohort suggests that as many as 84.6% of Swedish adolescents reported brushing twice daily (Källestål et al. 1990). This difference in the level of plaque control may influence the amount of calculus build-up, which has been shown to reduce or reverse the suppressive effect of smoking on gingival bleeding, particularly among light smokers (Dietrich et al. 2004). Furthermore, given that the suppressive effect of smoking on gingival bleeding is dose dependent, the difference in the findings in this study and those that have reported a suppressive or no significant effect of smoking on gingival bleeding may also be related to the fact that South African adolescents are mostly light smokers (most smoke 6–10 cigarettes/week) (Swart et al. 2004, Panday et al. 2007).

There was also evidence to suggest that the influence of smoking on adolescents' gingival health may be only partly mediated by the adolescents' SOC, as the inclusion of SOC

resulted in a slight attenuation of the effect of smoking. However, smoking remained independently associated with the self-reporting of frequent gingival bleeding. The fact that baseline plaque levels only became significant after controlling for SOC levels suggests that SOC (and by implication the ability to cope with stress) provided the context for the relevance of plaque levels. This finding supports the view that the influence of stress on periodontal health may be partly related to the fact that people who do not cope adequately with stress are also those who are more likely to neglect regular toothbrushing and thus experience inadequate plaque control, which may then directly influence periodontal or gingival health (Deinzer et al. 2005, Savolainen et al. 2005). It is also conceivable that plaque would have a greater adverse effect on the gingival health of people whose immune system is already compromised, as may be the case in the presence of stress (Ballieux 1991, Giannopoulou et al. 2003), which may in turn result from a low SOC. Given a stress-induced compromise of the immune response, it was not surprising to find that the final predictor model demonstrated an independent or a direct influence of SOC on gingival health, irrespective of subjects' oral hygiene status. This study's finding therefore corroborates findings from previous studies on the direct influence of inadequate stress-coping behaviour on periodontal disease (Genco et al. 1999, Wimmer et al. 2002).

The fact that a higher SOC seemed to protect subjects against poor gingival health is indeed consistent with the salutogenic theory (Antonovsky 1993). However, in contrast to our findings, a previous cross-sectional study showed no association between adolescents' SOC and gingival health measured by bleeding on probing (Freire et al. 2001). The differences in the findings may also be related to the differences in the diagnostic criteria used or in the study design. The episodic nature of gingivitis and the fact that SOC may be unstable during adolescence (Antonovsky 1993) may indeed explain the lack of a significant association between concurrent measures of adolescents' SOC and oral health status as observed in the previous cross-sectional study.

Nevertheless, the findings of this study should be considered in relation to its methodological strengths and limitations. A major limitation of this study is the reliance on self-reported tobacco use and self-reported gingival health, which may create potential reporting bias. However, adolescent self-reports of tobacco use have been generally found to be reliable (Post et al. 2005). Furthermore, the self-reporting of household income could also be considered fairly reliable, considering that the 72% obtained for those living in poor households in this study is consistent with the fact that 71% of children in the Limpopo Province have been estimated to be living with unemployed parents (Leatte 2006).

Self-reporting of gingivitis may also not have sufficient validity for screening individuals, but it has been demonstrated to be a useful method for monitoring the gingival health of adolescent populations (Kallio & Murtomaa 1997, Taani & Alhaija 2003). The alternative clinical diagnostic protocol (using probes to elicit the presence of gingival bleeding) was not carried out, as it was considered "invasive" and as the pilot test suggested that this would result in a high refusal rate. The high prevalence of HIV infection in South Africa (Department of Health 2005) and low literacy posed additional

challenges with regard to convincing potential participants that there was adequate infection control to guarantee the safety of the procedure. In addition, intra- and inter-examiner variations in "bleeding on probing" measurements are in themselves potential sources of measurement error (Kallio 1996). If anything, the use of self-reporting is more likely to have led to an underestimation than an overestimation of the associations reported in the current study. However, it should be noted that self-ratings of oral health have been suggested to be influenced by social class (Pattussi et al. 2007); therefore, the findings in this study may not be generalized to all adolescent populations.

Notwithstanding these limitations, a major strength of this study is that it involved a relatively large representative sample of adolescents in a resource-poor setting where access to regular professional oral care is not likely to have affected the "natural history" of periodontal disease (Baelum & Scheutz 2002). Furthermore, we used a longitudinal design with the GEE method, which limits the chance of sample bias (due to missing data) that may be encountered with longitudinal studies (Lee et al. 2007).

In conclusion, this study identified smoking and lower SOC as independent risk factors for poor gingival health among a rural population of adolescents with limited access to professional dental care. The study findings therefore suggest that integrating the promotion of stress-coping skills and smoking prevention with initiatives to improve oral hygiene performance among these adolescents may have a significant impact on periodontal disease prevention in the studied population.

Clinical Relevance

Scientific rationale for the study: Differences in coping with stress may confound the effect of smoking on periodontal health. We therefore examined the independent roles of smoking and SOC, a measure of stress coping, on self-reported gingivitis among South African adolescents over an 18-month period.

Principal findings: Only 22.9% had ever visited a dentist, 7% were regular smokers and 41.9% self-reported frequent gingival bleeding (gingivitis). Self-reported gingivitis was significantly less likely among those with a higher SOC, but was more likely among regular smokers, irrespective of plaque levels.

Practical implications: Smoking prevention, together with promoting stress-coping skills, may be useful additions to plaque control for promoting adolescents' gingival health.

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