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Periodontal Status as Mediator of the Association between Socioeconomic Status and Oral Health-Related Quality of Life in Pregnant Women

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Objective: To test periodontal status as a mediator between socioeconomic status (SES) and oral health-related quality of life (OHRQoL) in pregnant women. ***Basic research design***: Secondary cross-sectional analysis of baseline data from a randomised clinical trial with 303 pregnant women. ***Main outcome measures***: Demographic variables, SES, smoking, interproximal hygiene, and self-reported gingival bleeding were collected as independent variables. The Oral Health Impact Profile-14 was used to assess OHRQoL. The relationship between SES, periodontal status and OHRQoL was investigated in structural equation modelling. ***Results***: There was a moderate association of SES with periodontal status (standardised coefficient SC = -0.26, $p<0.01$) and number of teeth (SC = 0.24, $p<0.01$). Periodontal status and the number of teeth were also associated with OHRQoL (respectively, SC = 0.25, $p<0.01$ and SC = -0.31, $p<0.01$), but SES was only indirectly related to OHRQoL (SC = -0.17, $p<0.01$). Socioeconomic inequalities in quality of life were mainly explained by the remaining number of teeth, contributing to about 47%, and periodontal status, contributing to about 41%. ***Conclusions***: There was no direct effect of SES on OHRQoL in pregnant women. Periodontal status and missing teeth each explained almost half of the total indirect association.

Keywords*: Quality of life, periodontal diseases, oral health, socioeconomic status*

Introduction

Oral health-related quality of life (OHRQoL) is a construct based on the patient's perception of the impact of their oral health status on several aspects related to their ability and comfort with chewing, speaking, smiling, and being able not to feel physical, psychological or social disabilities when performing their daily activities. Patient-reported outcome measures (PROMS), such as the Oral Health Impact Profile 14 (OHIP-14) are tools that aim to capture OHRQoL to incorporate the patient's perspective of their oral health or treatment outcome, to complement the traditional clinical measurements of dental professionals (Hujoel, 2004).

Many sociodemographic and clinical factors have been associated with OHRQoL. Commonly, associations with age, sex, and the number of teeth have been shown, but socioeconomic status (SES) seems inconsistently reported (Santos *et al*., 2015; Vendrame *et al*., 2018). Periodontal status is associated with poor quality of life, but the strength of this association varies in epidemiological observational studies (Rebelo *et al*., 2016; Silva and Vettore, 2016; Sfreddo *et al*., 2019) and clinical trials (Shanbhag *et al*., 2012).

Socioeconomic status is a distal determinant of health and spreads its effect in different interweaved pathways. While ordinary regression methods allow only for estimating direct and independent associations, structural equations incorporate latent variables and deal with intermediate confounders, a situation where there are confounders for mediators (De Stavola et *al*., 2015). Periodontal status may play different roles in explaining the association between SES and OHRQoL (see supplementary Figure S1 at http://www.ufrgs.br/cpos/pesquisas/producao-cientifica). For example, periodontal status may be a mediator but also an intermediate confounding factor, if it is a risk factor for other mediators. It is essential to clarify such issues to understand and implement appropriate interventions to improve health. Therefore, this study aimed to test a mediation effect of periodontal status in the relation between socioeconomic status and OHRQoL.

Methods

This study is a cross-sectional analysis of data from a clinical trial of the effect of periodontal treatment on adverse pregnancy outcomes (Weidlich *et al*., 2013; Musskopf *et al*., 2018). The trial included 303 participants, from 357 recruited pregnant women, who sought prenatal care at the Hospital Materno Infantil Presidente Vargas (HMIPV), a public maternity hospital in Porto Alegre, Brazil, between April 2007 and June 2009. The response rate was 85%. For detailed information, the reader is referred to Weidlich et al. (2013). Participants were aged 18–35 years and had an obstetric ultrasound demonstrating a gestational age of ≤ 20 weeks. Women with multiple pregnancies, orthodontic appliances, or indications for antibiotic prophylaxis before dental care were excluded. This study was a secondary analysis of

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baseline data of all 303 participants. The HMIPV ethics board approved this study (no. 04/07) and it was conducted following the Helsinki Declaration of 1975, as revised in 2013. All patients gave written consent.

Demographic and socioeconomic data, information on smoking, interproximal hygiene, and self-reported gingival bleeding were obtained by an interview with each participant at the start of the study. The reproducibility of the interview data was checked by retesting 10% of the sample. Kappa coefficients varied from 0.77 to 0.84 for demographic, socioeconomic and smoking data.

Exposure to cigarette smoking was calculated for current and former smokers by multiplying the number of cigarettes smoked per day by the total number of days since the onset of smoking. This lifetime exposure to cigarettes was divided by 20 to yield the lifetime number of packs smoked (pack-years). Non-smokers were set at zero pack-years. Use of interproximal aids was assessed with the question "Do you use anything to clean between your teeth?" (yes or no); if the answer was positive, the next question was "When do you use this instrument?". This variable was categorised into regular interproximal cleaning (if the answer was 7 days/week) or irregular interproximal cleaning (defined as 1 to 6 days/week). Self-reported gingival bleeding was measured with the question "Do you observe bleeding gums?" (yes or no).

Oral health-related quality of life was measured with OHIP-14 using an overall score (Santos *et al*., 2013). The 14 items of OHIP-14 enquire about dysfunction, discomfort, and disability attributable to oral conditions on five-point Likert scales (never=0; hardly ever=1; occasionally=2; fairly often=3; and very often=4). The OHIP-14 score (i.e. sum of the item codes; possible range 0 to 56) was analysed as a one-factor latent variable, with a normalised score with mean equal to zero and variance equals to one (Santos *et al*., 2013). Higher values denote higher impact, or worse quality of life. The questionnaire was delivered in face-to-face interview performed by two trained interviewers. Participants used a hand card with the five possible answers (Musskopf *et al*., 2018).

Socioeconomic status (SES) was modelled as a latent variable, including three indicators: income (participant's income as a function of the minimum wage, MW), a household assets index, and years of study. The household assets index measured the purchasing power of the household as assessed by the Brazilian Economic Classification Criterion, which stratifies economic classes into A1, A2, B1, B2, C, D, or E based on education of the head of the house, and several specific household assets (having a TV, refrigerator, radio, DVD player, landline phone, car, laundromat, dishwasher). For purposes of analysis, classes D and E were pooled as "low economic class", class C was taken to represent middle class, and classes A and B were pooled as "high economic class".

Clinical examination of all teeth present other than third molars recorded the Silness-Löe plaque index, Löe gingival index, plaque retentive factors, probing depth, bleeding on probing, and the number of teeth. The reproducibility of probing depth measurements was tested before and during the study with an experienced periodontist (PW) as the reference. The intraclass correlation coefficient for PPD was 0.97 and 0.93 before and 0.95 and 0.96 during the study for intra and interexaminer reproducibility respectively. Periodontal status (PS) was analysed as a latent variable in the analysis based on visible plaque index, gingival index, periodontal pocket depth, bleeding on probing, and presence of plaque retentive factors. This approach can be considered as more parsimonious, as only one variable was analysed. It may also reduce random measurement error and avoid multicollinearity. Theoretically, pooling these variables into a single score assumes that they affect quality of life through the same pathways and are all mediators in the association between SES and quality of life.

Analyses

A polychoric correlation matrix among all observed ordinal and dichotomous variables and Pearson correlations among continuous variables formed the basis for Structural Equation Analysis (SEM). For the measurement model, the internal consistency was also calculated, i.e. Cronbach's alpha. The first step in the SEM produced an identified measurement model to test in Confirmatory Factor Analysis. This model evaluated how latent constructs are measured and how they performed in terms of measurement validity. After achieving an acceptable fit, the Structural Model was tested (Figure 1). The initial measurement model did not converge. To overcome this issue, multiple imputation was used to recover information for income (73 missing values) using household assets, years of study and age. Income was then described in five ordinal categories.

The initial structural model described the hypothesised paths among variables, estimating direct and indirect effects. We postulated the following direct associations based on a literature review (Figure S1, http://www.ufrgs.br/cpos/pesquisas/producao-cientifica): path 1, socioeconomic position leading to periodontal status (Borrell and Crawford, 2012) and path 2, socioeconomic position having a direct effect on OHRQoL (Ng and Leung, 2006). In the absence of empirical evidence, other paths were added based on plausible causal associations. The standardised coefficients (SC) of about 0.10 indicate a small effect, SC of about 0.30 indicates a moderate effect, and SC > 0.50 indicates a strong effect (Kline, 1994). The overall goodness-of-fit of the model to the data was evaluated using the ordinary comparative parameters provided by the software. Because we used categorical and ordinal variables, we used WLSMV estimator. Modification Indices (MI) of significant impact were investigated to improve model misfit and to include plausible alternative paths whilst maintaining parsimony. In this "Model Generating", MI values ≥20 were examined, as well as the theoretical meaningfulness of such changes. Paths where p>0.20 were removed. All analyses used Mplus version 7.11.

Results

The mean age of the participants was 25.85 ± 4.6 years, half had 9 to 11 years of education, and a similar proportion had medium SES (Table 1). About 72% of the sample had household per capita income equal or lower to three Brazilian minimum wages. Half the women were never smokers, did not perform interproximal hygiene or did so on an irregular basis. Most reported gingival bleeding. Means, standard errors and pairwise correlations among all variables included in the hypothesised model are available as supplementary material (Table S1 at http://www.ufrgs.br/cpos/pesquisas/

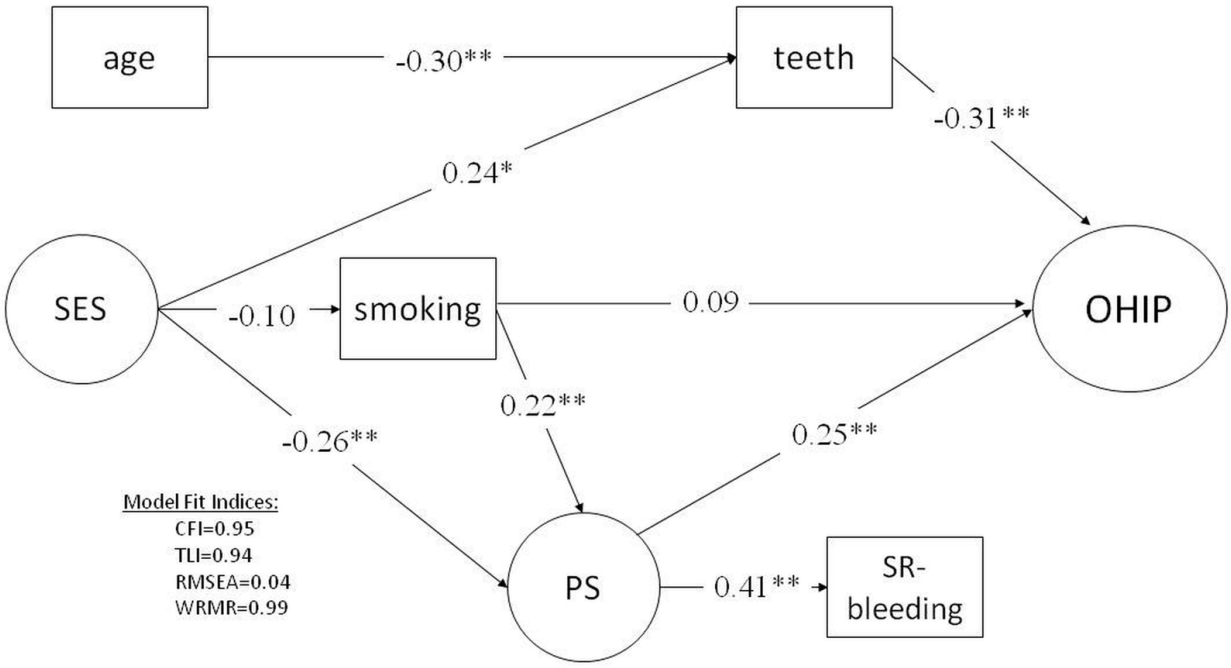

*Figure 1. Final structural equation model of the effects of socioeconomic status and periodontal status on oral health-related quality of life. SES = socioeconomic status, PS = periodontal status, OHIP = Oral Health Impact Profile, Teeth = number of teeth, Smoking = lifetime pack-years, Bleeding = self-reported bleeding gums.*p<0.05 **p<0.01*

producao-cientifica). Most of the correlation coefficients were of a low magnitude and ranged from -0.29 to 0.76.

The measurement model for three latent variables was very good (see supplementary table S2 at http://www.ufrgs.br/cpos/pesquisas/producao-cientifica) with loadings (Standardised Coefficients, SC) >0.40, showing that items were pertinent to the construct. Although the model needed additional residual correlations, the final showed very good fit: CFI= 0.97, TLI=0.96, RMSEA=0.04 and WRMR=0.86.

The initial structural model did not fit the data well (CFI = 0.93; TLI = 0.92; WRMR=1.03 and RMSEA = 0.04, Table 2). The interproximal hygiene variable showed a small coefficient (SC =0.06, p>0.20), with no association to any other variables, and so was removed. The final structural model, excluding interproximal hygiene, improved fit and was more parsimonious (CFI = 0.95; TLI = 0.94; WRMR=0.99 and RMSEA = 0.04. Figure 1 and Table 2)

The final model (Figure 1 and Table 2) indicates a moderate and direct inverse effect of SES on periodontal status (SC = -0.26, p=0.01), where higher SES is associated with poor periodontal status. Periodontal status was moderately associated with OHRQoL (SC = 0.25, p<0.01). In this context, the lower the SES, the worse the periodontal status and the higher the OHIP scores among pregnant women. Higher SES predicted more remaining teeth (SC = 0.24, p=0.02) and more teeth predicted lower impact on oral health on quality of life (SC = -0.31, p<0.01). SES also showed a small and direct inverse effect on smoking (SC = -0.10, p=0.10), and smoking had a small direct association with quality of life (SC = 0.09, p=0.06).

The total, direct and indirect effects of socioeconomic status on oral health-related quality of life for initial and final models are shown in Table 3. The effect of SES on OHRQoL (SC= -0.17, p<0.01) was entirely indirect, 47% of which was mediated by the number of teeth and 41% by periodontal status (including an additional mediation via SES > smoking > periodontal status-> OHIP).

Discussion

This study observed that the effect of socioeconomic status on OHRQoL is indirect and mainly explained by periodontal status and the number of present teeth, contributing about 41% and 47%, respectively. Notably, there was a small direct effect and four indirect pathways. Periodontal status was the only mediator in one pathway, smoking in another, while both were mediators in a third path, having the number of teeth a sole mediator in the fourth path.

Poorer periodontal status has been associated with negative impacts on OHRQoL. Individuals with periodontal attachment loss (Jansson *et al*., 2014) or periodontitis (Bernabé and Marcenes, 2010) have worse OHRQoL than healthy ones, and periodontitis remained moderate and significant even after adjustment for demographic factors, socioeconomic status and the number of teeth (Bernabé and Marcenes, 2010), consistent with the independent direct effect observed here.

Interproximal hygiene was removed from the final model. Interproximal hygiene is widely recommended for periodontal disease prevention (Sälzer *et al*., 2015). Nonetheless, adherence to daily dental flossing is low (Sambunjak *et al*., 2019), perhaps explained by lack of motivation and skills (Schüz *et al*., 2009). These results are in line with a systematic review that demonstrated no additional effect of flossing compared to toothbrushing alone in reducing plaque and gingivitis (Berchier *et al*., 2008). In contrast, another systematic review evaluated twelve clinical trials showed an 8% additional reduction in gingivitis at six months for flossing when combined with toothbrushing (Sambunjak et al., 2019). Interestingly, other studies had shown that interproximal hygiene (flossing) is unrelated to OHRQoL in adults (Dahl *et al*., 2011) and orthodontic patients (Zanatta *et al*., 2012).

This one of few studies to assess the contribution of periodontal status to explain socioeconomic inequalities in

Table 1. Characteristics of 303 pregnant women.

	%
Purchasing power	
Low	22.4
Medium	51.2
High	26.4
Years of study	
<=8 years	36.3
9-11 years	52.1
>=12 years	11.6
Income (minimum wage MW)	
Up to 1 MW	19.5
1 to 3 MW	28.4
More than 3 MW	10.9
Not informed	17.2
None	24.1
Smoking	
Non-smoker	51.8
Smoker	17.8
Former smoker	30.4
Interproximal hygiene	
No	31.7
Irregular	33.3
Regular	34.9
Self-reported gingival bleeding	
No	26.4
Yes	73.6
	Mean (sd)
OHIP-14 score	13.5 (9.1)
Periodontal parameters	
Plaque Index	1.4 (0.5)
Gingival Index	1.3 (0.2)
Supragingival calculus (% sites)	26.2 (16.3)
BOP (% sites)	49.5 (20.8)
PPD (mm)	2.6 (0.3)
PPD ≤ 3mm (% sites)	89.2 (10.4)
PPD ≥4mm (% sites)	10.8 (10.3)
Number of teeth	25.2 (4.3)

Table 2. Fit of initial and final structural equation models among 303 pregnant women.

Independent Variables	*Outcomes*	*Initial Model SC*	*p-value*	*Final Model SC*	*p-value*
SES (Latent)	Smoking	-0.13	0.15	-0.10	0.10
	Teeth	0.19	0.12	0.24	0.02
	PS	-0.21	0.13	-0.26	0.01
	OHIP	-0.04	0.53		
	Interproximal aid	0.05	0.46		
PS (Latent)	Teeth	-0.02	0.77		
	OHIP	0.23	<0.01	0.25	<0.01
	Bleeding (self-reported)	0.42	<0.01	0.41	<0.01
Smoking	OHIP			0.09	0.06
	PS	0.25	<0.01	0.22	<0.01
	Teeth	-0.08	0.26		
Age	Teeth	-0.29	<0.01	-0.30	<0.01
	PS	0.08	0.26		
	PS	-0.08	0.21		
Interproximal aid	Bleeding (self-reported)	0.03	0.66		
Teeth	OHIP	-0.29	<0.01	-0.31	<0.01
Bleeding (self-reported)	OHIP	0.07	0.47		
Model Fit					
CFI		0.93		0.95	
TLI		0.92		0.95	
RMSEA		0.04		0.04	
WRMR		1.03		0.99	

SES: socioeconomic status, PS: periodontal status; OHIP: Oral Health Impact Profile, CFI: comparative fit index; TLI: Tuker-Lewis Index; RMSEA: root mean square error of approximation, WRMR: weighted root mean residuals

OHRQoL using methods to decompose total effect. Rebelo et al. (2016) showed that periodontal disease is a major mediator between income and OHRQoL using Wilson and Cleary's theoretical model, with no direct effect of income on quality of life. That study, as did this one, demonstrated the value of alternative approaches to understanding the association between OHRQoL and periodontal status, and in this sense, SEM is a more comprehensive analysis (Celeste, 2020). Some previously reported associations were confirmed in this specific group, which leads supports our results explaining the association between SES and OHRQoL.

The model was able to explain the effect of SES on OHRQoL. Limitations of this study include the use of cross-sectional data, in which the model assumes causality on theoretical grounds without time-relations. The sample represented a specific group (pregnant women) and selection bias, inducing some associations, cannot be excluded (Celeste, 2020). Measurement bias may also be present for self-reported variables such as interproximal hygiene. Additionally, alternative hypotheses may be possible, although likely relevant variables were included. The final model was partially based on statistical grounds, which should be acknowledged as a "model generating" study, which could help to develop a more robust model.

In conclusion, this study described the contribution of periodontal status and missing teeth to explain the effect of SES on OHRQoL in pregnant women. For policy-makers and clinicians, this result does not support prioritising actions towards periodontal outcomes or missing teeth, as both had a similar contribution in explaining socioeconomic inequalities in OHRQoL. Other oral diseases may also have a role in more complex pathways, given that SES has several oral outcomes. Future studies may test other mediators, including relevant risk factors such as smoking.

Table 3. Total and indirect effects of socioeconomic and periodontal status on OHRQoL in initial and final models.

	Initial		*Final*	
SES on OHRQoL	*Standardised Coefficient*	*p*	*Standardised Coefficient*	*p*
Total Effect	-0.19	0.01	-0.17	<0.01
Direct:	-0.04	0.53	--	--
Indirect:	-0.15	<0.01	-0.17	<0.01
SES- teeth- OHRQoL	-0.06	0.02	-0.08	0.05
SES-smoke-PS-OHRQoL	-0.02	0.04	-0.01	0.13
SES-smoke-OHRQoL	--	--	-0.01	0.23
SES-PS- OHRQoL	--	--	-0.07	0.04
SES -interaid- teeth-OHRQoL	<0.01	0.63	--	--
SES -interaid- PS-OHRQoL	<0.01	0.55	--	--
SES-interaid-PS-bleeding- OHRQoL	<0.01	0.62	--	--
SES-smoke-PS-bleeding- OHRQoL	<0.01	0.46	--	--
SES-interaid-PS-teeth- OHRQoL	<0.01	0.58	--	--
SES-smoke-PS-teeth-OHRQoL	<0.01	0.21	--	--

Teeth: number of teeth; smoke: lifetime exposure to tobacco; bleeding: self-reported bleeding gums.

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