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Title: Low social position, periodontal disease and poor oral health-related quality of life in adults with systemic arterial hypertension

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Conflict of Interest
The authors declare that there are no conflicts of interest in this study.

A one-sentence summary describing the key finding(s)
Periodontal disease predicted poor OHRQoL and mediated the link between smoking, socioeconomic status and OHRQoL in people with systemic arterial hypertension.

Key words: Periodontitis; Quality of life; Hypertension

Abstract

Background: There is little evidence on the association between periodontal disease and oral health-related quality of life (OHRQoL) in individuals with chronic diseases, including hypertension. The aim of this study is to identify the relationships between sociodemographic characteristics, smoking, tooth loss, dental caries, periodontal status and OHRQoL in adults with systemic arterial hypertension.

Methods: A cross-sectional study involving 195 adults (mean age 55.7 years) with systemic arterial hypertension used interviews and oral examinations to collect data on sociodemographic characteristics (age, sex and income), use of antihypertensive, smoking, tooth loss, dental caries, periodontal status (bleeding on probing, calculus and attachment loss) and oral health-related quality of life (OHRQoL/OHIP-14). Wilson and Cleary's conceptual model was used to test the direct and indirect relationships between variables using structural equation modeling.

Results: Lower age, male sex, smoking and lower income directly predicted worse periodontal status. Tooth loss, dental caries, worse periodontal status and smoking were directly linked to poor OHRQoL. Age was indirectly linked to worse periodontal status via income. Income and smoking indirectly predicted poor OHRQoL via periodontal status.

Conclusions: The findings support an effect of periodontal disease on OHRQoL in people with systemic arterial hypertension. Periodontal status mediated the associations of sociodemographic characteristics and smoking with OHRQoL through different pathways.

Introduction

Systemic arterial hypertension is a major global chronic condition related to millions of premature deaths. [1] Approximately 54% of stroke and 47% of ischemic heart disease are linked to high blood pressure worldwide. [1] Moreover, 80% of the deaths attributable to hypertension occur in low- and middle-income countries, and 50% occurred in people aged between 45 and 69 years.[1] Previous studies showed impaired health-related quality of life among subjects with hypertension.[2,3] This makes systemic arterial hypertension a public health priority.

Periodontal diseases compose a group of chronic inflammatory conditions affecting the tooth-supporting tissues with a global prevalence of severe periodontitis of 10.8% or 743 million people worldwide.[4] The onset and progression of periodontal diseases are associated with microbiological changes and increase in the levels of inflammatory mediators (eg. C-reactive protein) in the periodontal tissues.[5,6] Research on this topic has been largely conducted within the biomedical model of health and disease. However, chronic periodontal disease manifests signs and symptoms related to gingival inflammation and loss of supportive periodontal tissues which may impact on quality of life.[7] Oral health-related quality of life (OHRQoL) is measured using multidimensional subjective indicators of functional, psychological and social aspects of the impact of oral conditions on oral function and well being.[8]

Previous studies have reported negative impacts of periodontal diseases on OHRQoL.[9-14] However, a recent systematic review highlighted critical issues and potential flaws in previous research, including the lack of control for confounding, such as tooth loss, dental caries or other variables in adjusted analyses.[15] Our knowledge of the impact of periodontal diseases on OHRQoL relies on research involving systemically healthy persons, whereas evidence in individuals with chronic disease is scarce. Periodontal disease has been associated with poor OHRQoL in diabetic patients.[16-18]

However, a recent contradictory study reported no impact of periodontal disease on OHRQoL in patients with diabetes.[19]

Since periodontal disease and heart diseases share common risk factors and both predict health-related psychosocial outcomes, it may be that their effects are cumulative.[20] That is, periodontal disease may further influence HRQoL in individuals with systemic arterial hypertension. Futhermore, no study of the relationship between periodontal disease and OHRQoL has employed a conceptual theoretical model to assess the simultaneous relationships of periodontal status, sociodemographic characteristics, tooth loss and smoking with OHRQoL.

The identification of the predictors of OHRQoL in adults with systemic arterial hypertension, including periodontal disease, is relevant because the underpinning mechanisms by which these determinants influences OHRQoL are poorly understood.[15] A better understanding of the pathways through which clinical, individual and environmental factors affect adult's quality of life related to oral diseases would support the development of person-centered approaches to oral health care as well as oral health promotion strategies.

With these points in mind we investigated OHRQoL in individuals with systemic arterial hypertension using the Wilson & Cleary conceptual model.[21] According to this model, different outcomes are organised across: (1) biological and physiological variables, (2) symptoms, (3) functional status, (4) general health perceptions and (5) overall quality of life. Causal links may also exert between adjacent and non-adjacent levels creating a complex theoretical model that can be analyzed in a structural equation model which has the advantage of elucidating direct and indirect relationships between multiple independent variables and the outcome simultaneously.[22] Compared with traditional regression analysis, the above mentioned approach is theoretically driven and in accordance with the biopsychosocial model of health, which in turn considers the

biological, psychological and social factors related to health outcomes. It should be noted that rather than being a model of disease aetiology, the Wilson and Cleary model theorises the consequences of the biological state.[21] However, the model can be amended to incorporate aspects of aetiology by adding links from risk factors for disease, such as age, sex, income and tobacco smoking as predictors of periodontal disease.[23]

The present study aims to identify the relationships between periodontal status, sociodemographic characteristics (age, sex and income), smoking, duration of hypertension, tooth loss, dental caries and OHRQoL in adults with systemic arterial hypertension, using the Wilson and Cleary conceptual model[21] (Figure 1).

Patients and Methods

Study Design

This was a cross-sectional study conducted from October to December 2014 in patients with systemic arterial hypertension seeking care in primary health care units participating in the *Hiperdia* program in the urban areas in the city of Manaus/AM, Brazil. *Hiperdia* is a national public program coordinated by the Brazilian National Health Care System (Unified Health System – SUS) intended to monitor and to provide free of charge treatment and medications for individuals with systemic arterial hypertension and/or diabetes mellitus. The *Hiperdia* program also coordinates the distribution of medicines to all registered patients.

Sampling process

A two-stage sampling process first involved a random selection of primary health care units participating in the *Hiperdia* program in Manaus. The probability of selection was proportional to the size of the five administrative zones of the city. Of the 211 primary health care units, 28 were randomly selected. In the second stage, all of adult patients

with systemic arterial hypertension in each health care unit were invited to participate until the sample size has been achieved.

Sample size calculation

A sample size of 200 people was estimated to detect a minimum effect size of 0.1 with a power 80 % and 5 % of significance (α = 0.05) in a structural equation model directed towards hypothesis testing for complex models with 2 latent variables and 6 observed variables.[24]

Selection criteria

Eligible patients were adults of at least 18 years of age with clinically diagnosed systemic arterial hypertension who were registered in the *Hiperdia* program. The diagnosis was based on systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg confirmed by repeated measurements on at least three different occasions.[25] Adults with diabetes mellitus (fasting plasma glucose concentration > 126.0 md/dl) and pregnant women were excluded.

Periodontal status assessment

A single calibrated dentist (PHDFC) assessed the Community Periodontal Index (CPI), including measures of bleeding on probing (BOP), calculus and periodontal probing.[26] In addition, the worst attachment loss (AL) score for each sextant was registered. CPI and AL measures were registered for each sextant at the six CPI index teeth using a plain dental mirror[‡] and a CPI probe[§].

Periodontal status was treated as a latent variable measured by three clinical indicators: BOP, calculus and AL. BOP was coded as "0 = sound" or "1 = BOP" for each sextant. Calculus was coded as "0 = sound" or "1 = calculus" for each sextant. AL was registered in each sextant as "0 = 0-3 mm", "1 = 4-5 mm", "2 = 6-8 mm", "3 = 9-11 mm" and "4 = ≥ 12 mm". Then, the codes were summed to obtain a final periodontal status score for each person, with a final score ranging from 0 to 36. The higher final scores

6

denote worse periodontal status. Since periodontal probing comprise part of the AL measure, the former was not considered in the periodontal status latent variable as this would overestimate the score.

Tooth loss and decayed teeth

Tooth loss and decayed teeth were assessed according to the number of missing natural teeth (including third molars) and number of teeth with current dental caries.[27] The component D of the DMFT index was employed to assess the number of teeth due to dental caries.

Reliability study

Intra-examiner reliability for clinical measures was assessed in 20 patients selected from primary health care units not included in the main study who were examined with seven-day intervals between examinations. Reliability between measures was tested using Kappa statistics. Kappa coefficients were 0.95 for DMFT index, 0.68 for CPI codes and 0.70 for AL.

Sociodemographic characteristics, smoking and duration of hypertension

Sociodemographic characteristics included age, sex and monthly family income. Individuals who had smoked tobacco cigarettes at least once were considered smokers. Smokers were classified according to the age of smoking initiation: <15; 15-16; 17-19 and ≥20 years-old.[28] Age was recorded according to the date of birth. Monthly family income was registered as an ordinal variable across four groups: ≤ 250; 251-500; 501-1500; ≥ 1500 Brazilian Reais (one US$ corresponds to 2.26 Brazilian Reais). Duration of hypertension was registered in years based on the time interval since the individual was diagnosed with hypertension.

Oral health-related quality of life

Oral health-related quality of life was a latent variable evaluated using the Brazilian version of the Oral Health Impact Profile (OHIP-14).[29,30] OHIP-14 is a multidimensional

instrument that measures the frequency of problems associated with mouth on seven distinct conceptual dimensions: functional limitation (eg. difficulty chewing), physical pain (pain in mouth and discomfort eating foods), psychological discomfort (feeling self-conscious and tense), physical disability (interrupted meals and unsatisfactory diet), psychological disability (difficulty to relax and embarrassment), social disability (avoiding social interaction) and handicap (inability to function). The OHRQoL latent variable was measured by the seven subscales (indicators), representing the OHIP-14 dimensions. The responses are in an ordinal scale coded: 0=never, 1=hardly ever, 2= occasionally, 3= fairly often, 4=very often.[29] OHIP-14 scores were computed by summing the code responses within each dimension to obtain the subscales scores. The internal reliability (Cronbach's alpha) was 0.79 for the OHIP-14 scale.

Data Collection

Initially the medical records of patients with medical appointments for systemic arterial hypertension control in primary care units participating on the day of data collection were scrutinized. All patients received written information concerning the study aims and procedures.

After obtaining written agreement for their participation, data were collected through individual structured interviews and clinical oral examination at the dental office located in the health care units. The interviews and examinations were conducted in the dental offices of the health care units.

The study was approved by the Ethics Committee on Human Research of the Federal University of Amazonas, registration CAAE 30667614.5.0000.5020.

Statistical analysis

The hypothesized measurement model was tested through confirmatory factor analysis (CFA) which determined the associations between the latent variables and their observed measures, as follows: periodontal status (latent variable) measured by BOP, calculus and

8

AL, and OHRQoL (latent variable), measured by the seven OHIP-14 subscales. After that, structural equation modeling examined the direct and indirect relationships between the observed variables (tooth loss, decayed teeth, sex, age, income, smoking and duration of hypertension) and latent constructs (periodontal status and OHRQoL) within the Wilson and Cleary conceptual model.[21] We predicted *a priori* that environment (low income) and individual (higher age and smoking) characteristics would predict worse periodontal status and poor OHRQoL. In accordance with the theoretical model, it was hypothesized that low income would directly predict more tooth loss, more decayed teeth and smoking, and that greater age and smoking would predict worse periodontal status, more tooth loss, and poor OHRQoL (Figure 1).

The total effect, which represents the direct link from one variable to another plus the indirect effects where the path is mediated by others variables was estimated by AMOS. Total indirect effects represent the sum of one or more specific paths. Bias-corrected bootstrap CI was used to assess mediation by analysing the statistical significance of indirect effects.[31]

Maximum likelihood estimation and bootstrapping were estimated using AMOS 22.0. Nine hundred bootstrap samples were re-sampled from the original data set to derive less biased standard errors and 95% confidence interval (CI) bootstrap percentiles. The Chi-square test statistic was used to assess the adequacy of overall model fit. We also used the root-mean squared error of approximation (RMSEA) with 90% CI, Standardized Root Mean Square Residual (SRMR), and Goodness of Fit (GFI), and the Comparative Fit Indices (CFI). The threshold for a good model fit was χ^2/df ratio < 3.0, SRMR $\leq$0.08, RMSEA $\leq$0.06 and GFI and CFI values $\geq$0.90.[32]

Results

The sample consisted of 201 adults with systemic arterial hypertension. The non-response rate was 0.5% (N = 1). Five participants were excluded due to incomplete data, yielding a final sample of 195 adults (67.7% women) with systemic arterial hypertension. The mean age of the sample was 55.7 years (SD = 13.9) and 75.4% reported smoking tobacco once in their lives. The mean tooth loss and decayed teeth were 20.3 teeth (SD = 10.8) and 2.3 teeth (SD = 4.3) respectively. Of the participants, 29.2% were edentulous, 8.2% use upper partial dentures and 3.6% use lower partial dentures. The prevalence of at least one sextant with BOP and calculus were 44.1% and 47.2%, respectively. Fifty-seven percent of the sextants could not be examined due to tooth loss, however 29.1% showed AL 0-3 mm and 10.5% showed AL 4-5 mm. The mean OHIP-14 score was 9.4 (SD = 9.4) (Table 1).

Confirmatory factor analysis (CFA) assessed the measurement model (Figure 2) for individual latent factors, namely periodontal status and OHRQoL. The item loadings confirming the latent variable "periodontal status" were BOP (β= 0.827), Calculus (β= 1.063) and AL (β= 0.468). The item loadings confirming OHRQoL were functional limitation (β= 0.707), physical pain (β= 0.424), psychological discomfort (β=0.729), physical disability (β= 0.491), psychological disability (β= 0.696), social disability (β= 0.472), and handicap (β=0.201). The highest R^2 were 1.13 (Calculus) and 0.53 (psychological discomfort) for the periodontal status and OHRQol latent variables, respectively.

The CFA statistical fit indices for the full model, measurement model and parsimonious model are presented in Table 2. The full and measurement models were acceptable fits to the data, meeting all the five *a priori* criteria. The non-significant direct hypothesized paths were removed from the full model, which was re-estimated to obtain a statistically parsimonious model. The variable duration of hypertension was removed from the parsimonious model as it was unrelated to any other variable.

10

The direct and indirect paths in the parsimonious model are summarized in Figure 3 and Table 3. The direct paths showed that being older was linked to lower income (β= -0.161); but being younger was related to worse periodontal status (β= -0.372). Being older (β= 0.534) and male (β= 0.105) were linked to more tooth loss. Lower income (β= -0.316) and smoking (β= 0.115) were also linked to poor periodontal status. Poor OHRQoL was directly predicted by smoking (β= 0.172), more lost teeth (β= 0.273), more decayed teeth (β= 0.198) and worse periodontal status (β= 0.293). As shown in Figure 3 and in line with our hypothesis derived from the conceptual model, smoking, periodontal status and tooth loss directly predicted OHRQoL.

There were significant indirect relationships between observed and latent variables. Age was indirectly linked to periodontal status (β= 0.051). Smoking (β= 0.034) and income (β= -0.092) predicted OHRQoL indirectly. The total indirect effects seen in Figure 3 comprise specific indirect paths which were calculated as follows (all values are standardized beta coefficients):

1. Age to periodontal status

Younger age $\rightarrow$ lower income $\rightarrow$ worse periodontal status = -0.161 x -0.316 = 0.051

2. Smoking to OHRQoL:

Smoking $\rightarrow$ worse periodontal status $\rightarrow$ worse OHRQoL = 0.115 x 0.293 = 0.034;

3. Income to OHRQoL:

Lower income $\rightarrow$ worse periodontal status $\rightarrow$ worse OHRQoL = -0.316 x 0.293= -0.093.

Discussion

We investigated the relationships between individual and environmental characteristics (age, sex, duration of hypertension and income), smoking, periodontal

11

clinical measures, tooth loss, decayed teeth and OHRQoL in adults with systemic arterial hypertension. An explicit hypothesized theoretical model was employed and tested using structural equation modeling, which is an appropriate approach to assess simultaneous relationships in complex models.[31] Poor periodontal status, tooth loss, decayed teeth and smoking directly predicted worse OHRQoL in adults with systemic arterial hypertension. Interestingly, worse periodontal status showed the strongest effect on poor OHRQoL, followed by tooth loss and decayed teeth. Thus, our findings support the hypothesis that periodontal diseases have negative impacts on OHRQoL in individuals with this chronic condition. Moreover, different direct and indirect links were identified. Male sex, smoking and lower age predicted poor periodontal status. Age was also inversely related to income. Low income and smoking predicted poor OHRQoL mediated through periodontal status.

The goodness of fit of the parsimonious model supports the application of the Wilson and Cleary theoretical framework in adults with systemic arterial hypertension. Previous studies also support to Wilson and Cleary´s conceptual model[21] of OHRQoL measures as applied to patients with xerostomia[33], children[34], adults with low levels of caries and treatment experience[35] and edentulous older adults[36]. However, to the best of the authors' knowledge this is the first study that has reported a significant link between periodontal clinical measures and OHRQoL using the Wilson and Cleary model.

As predicted, periodontal disease was related to poor OHRQoL.[13,14,17,19,37-41] Nevertheless, previous studies show several methodological variations. These studies have included younger[38] and older adults[37,40], and different statistical approaches, including bivariate analysis[17,19], the minimally important difference[14] and regression models[13,39,40] were adopted. Other important variations relate to the measures employed to assess periodontal status and inconsistent control for confounding. The inconsistent control for confounding was highlighted as a limitation that may affect the validity of

some findings[15], but was addressed in the present research by including sociodemographic factors, tooth loss, decayed teeth and smoking in the structural equation modeling. OHRQoL has predominantly been assessed using OHIP in these studies, which might explain the consistency in findings.

In these data, smoking predicted poor periodontal status and worse OHRQoL. Earlier studies indicate that smoking is associated with greater prevalence and severity of periodontal disease.[42,43] Moreover, smokers had lower OHRQoL than non-smokers.[44]

The association between low income and periodontal disease has been extensively demonstrated in the literature.[45,46] However, the mediating effect of periodontal status on the link between income and OHRQoL represents a new finding. Previous studies adjusted the relationship between periodontal disease and OHRQOL for socioeconomic factors, since it was considered a confounding variable.[13]

In this study, we have simultaneously shown adverse relationships between socioeconomic status, smoking and periodontal status on OHRQoL, adding to the burden of ill-health of people with hypertension. There are potential implications of these findings regarding strategies in oral health promotion and prevention for people with systemic arterial hypertension. Oral health professionals should engage with other health professionals and other sectors of society to reduce smoking and improve periodontal health through population strategies. This would improve OHRQoL as well as people's general health and longevity.

The association between tooth loss and OHRQoL is in agreement with a systematic review that supports this relationship.[47] Age has been consistently identified as risk for periodontal disease.[48] However, our results revealed that age was inversely associated to periodontal status. This unexpected result probably occurred because greater age is related to more tooth loss, which in turn reduces the prevalence of severe periodontal disease.

Some limitations of this study must be considered. Our cross-sectional design restricts the interpretation of the causal processes underlying the associations reported in the structural equation modeling.[49] Periodontal status was assessed using bleeding on probing, calculus and AL measures for each sextant. The lack of full periodontal examination (six sites per tooth in all teeth) and the use of CPI index might underestimate disease levels[50] and therefore attenuate the apparent relationships. Nevertheless, the link between periodontal disease and OHRQoL was significant. The validity of the smoking measurement used in this study is questionable since it may not reflect the extent of smoking exposure. Furthermore, the information about smoking at least once may overestimate current regular smokers and the information about former smokers was not recorded. Although the structural equation modeling resulted in age-adjusted estimates, the age range of the sample was wide. This might resulted in the inclusion of different periodontal conditions. Future studies should consider using a narrower age range.

Although studies examining the association between periodontal disease and OHRQoL should include only dentate participants, the present research investigated other relationships such as the link between tooth loss and OHRQoL. In the present study, the link between periodontal disease and OHRQoL analyzed in a structural equation model of a subsample of dentate participants ($\beta = 0.273$, $P < 0.05$) was similar to the findings of the full sample with dentate and edentulous adults ($\beta = 0.239$, $P < 0.01$). This suggests that our results were not influenced by the inclusion of edentulous adults.

Although the impact of periodontal disease on OHRQoL is a consistent finding in studies of individuals without systemic conditions, this association has been little explored in patients with chronic disease. Impacts of periodontal disease on the quality of life of individuals with diabetes have been demonstrated.[16-18] Our findings are compatible with a role for periodontal disease on OHRQoL in adults with systemic arterial hypertension. Periodontal disease and hypertension share common risk factors

and one can argue that the burden of these conditions on OHRQoL appears to be cumulative. Therefore, studies involving people with and without periodontal disease and hypertension may elucidate the extent to which risk factors are cumulative for both diseases and on psychosocial patient reported outcomes. Further investigations involving patients with different chronic conditions are required to clarify whether periodontal disease and maybe other oral health problems are relevant predictors for OHRQoL.

Conclusion

The present study is the first to provide evidence of the importance of periodontal status on OHRQoL as well as the mediating effect of periodontal status on the link between smoking, socioeconomic status (income) and OHRQoL in people with systemic arterial hypertension using a theoretical model. Our findings suggest the potential benefits of preventive actions related to oral health such as maintenance of natural teeth, prevention and control of periodontal disease as well smoking reduction to improve OHRQoL in patients with systemic arterial hypertension.

Conflict of interest statement

The authors report no conflicts of interest related to this study.

References

15

1. Lawes CM, Vander Hoorn S, Rodgers A, International Society of Hypertension. Global burden of blood pressure related disease. 2001. *Lancet* 2008;371:1513-1518.

2. Alonso J, Ferrer M, Gandek B, et al. Health-related quality of life associated with chronic conditions in eight countries: results from the International Quality of Life Assessment (IQOLA) Project. *Qual Life Res* 2004;13:283-298.

3. Wang R, Zhao Y, He X, et al. Impact of hypertension on health-related quality of life in a population based study in Shanghai, China. *Public Health* 2009;123:534-539.

4. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of severe periodontitis in 1990-2010: a systematic review and meta-regression. *J Dent Res* 2014;93:1045-1053.

5. Joshipura KJ, Wand HC, Merchant AT, Rimm EB. Periodontal disease and biomarkers related to cardiovascular disease. *J Dent Res* 2004;83:151-155.

6. Winning L, Patterson CC, Cullen KM, et al. The association between subgingival periodontal pathogens and systemic inflammation. *J Clin Periodontol* 2015;42:799-806.

7. Locker D. Measuring oral health: a conceptual framework. *Community Dent Health* 1988;5:3-18.

8. Sischo L, Broder H. Oral health-related quality of life: what, why, how, and future implications. *J Dent Res* 2011;90:1264-1270.

9. Reisine ST, Fertig J, Weber J, Leder S. Impact of dental conditions on patients' quality of life. *Community Dent Oral Epidemiol* 1989;17:7-10.

10. Needleman I, McGrath C, Floyd P, Biddle A. Impact of oral health on the life quality of periodontal patients. *J Clin Periodontol* 2004;31:454-457.

11. Brennan DS, Spencer AJ, Roberts-Thomson KF. Quality of life and disability weights associated with periodontal disease. *J Dent Res* 2007;86:713-717.

12. Cunha-Cruz J, Hujoel PP, Kressin NR. Oral health-related quality of life of periodontal patients. *J Periodontal Res* 2007;42:169-176.

13. Bernabé E, Marcenes W. Periodontal disease and quality of life in British adults. *J Clin Periodontol* 2010;37:968-972.

14. Tsakos G, Bernabé E, D'Aiuto F, et al. Assessing the minimally importance difference in the Oral Impact on Daily Performances index in patients treated for periodontitis. *J Clin Periodontol* 2010;37:903-909.

15. Al-Harthi LS, Cullinan MP, Thomson WM. The impact of periodontitis on oral health-related quality of life: a review of the evidence from observational studies.

Aust Dent J 2013;58:274-277.

16. Drumond-Santana T, Costa FO, Zenóbio EG, Soares RV, Santana TD. Impact of periodontal disease on quality of life for dentate diabetics. *Cad Saúde Pública* 2007;23:637-644.

17. de Pinho AMS, Borges CM, Abreu MHNG, Ferreira EF, Vargas AMD. Impact of periodontal disease on the quality of life of diabetics based on different clinical diagnostic criteria. *Int J Dent* 2012;2012:986412.

18. Mohamed HG, Idris SB, Ahmed MF, et al. Association between oral health status and type 2 diabetes mellitus among Sudanese adults: a matched case-control study. *PLoS One* 2013;8:e82158.

19. Irani FC, Wassall RR, Preshaw PM. Impact of periodontal status on oral health-related quality of life in patients with and without type 2 diabetes. *J Dent* 2015;43:506-511.

20. Sheiham A, Watt RG. The common risk factor approach: a rational basis for promoting oral health. *Community Dent Oral Epidemiol* 2000;28:399-406.

21. Wilson IB, Cleary PD. Linking clinical variables with health-related quality of life. *JAMA* 1995;273:59-65.

22. Kline RB. *Principles and practice of structural equation modelling*, 2nd edn. New York: The Guildford Press; 2005:91-122.

23. Genco RJ, Borgnakke WS. Risk factors for periodontal disease. *Periodontology 2000* 2013;62:59-94.

24. Westland JC. Lower bounds on sample size in structural equation modeling. *Electron Commer R A* 2010;9:476-487.

25. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension* 2003;42:1206-1252.

26. Ainamo J, Barmes D, Beagrie G, Cutress T, Martin J, Sardo-Infirri J. Development of the World Health Organization (WHO) community periodontal index of treatment needs (CPITN). *Int Dent J* 1982;32:281-291.

27. World Health Organization. *Oral health surveys-basic methods*. 4th ed. Geneva: World Health Organization; 1997: 39-46.

28. Instituto Brasileiro de Geografia e Estatıstica (IBGE). *Pesquisa Nacional de Saúde Escolar (PeNSE), 2012*. Rio de Janeiro (RJ): IBGE; 2012.

29. Slade GD, Spencer AJ. Development and evaluation of the oral health impact profile. *Community Dent Health* 1994;11:3-11.

30. Oliveira BH, Nadanovsky P. Psychometric properties of the Brazilian version of the Oral Health Impact Profile–short form. *Community Dent Oral Epidemiol* 2005;33:307-314.

31. MacKinnon DP, Lockwood CM, Hoffman JM, West SG, Sheets VA. Comparison of methods to test mediation and other intervening variable effects. *Psychol Methods* 2002;7:83-104.

32. Hu L-T, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equ Modeling* 1999;6:1-55.

33. Baker SR, Pankhurst CL, Robinson PG. Testing relationships between clinical and non-clinical variables in xerostomia: A structural equation model of oral health-related quality of life. *Qual Life Res* 2007;16:297-308.

34. Gururatana O, Baker SR, Robinson PG.Determinants of children's oral-health-related quality of life over time. *Community Dent Oral Epidemiol* 2014;42:206-215.

35. Gupta E, Robinson PG, Marya CM, Baker SR. Oral health inequalities: Relationships between environmental-individual factors. *J Dent Res* 2015;94:1362-1368.

36. Baker SR, Pearson NK, Robinson PG. Testing the applicability of a conceptual model of oral health in housebound edentulous older people. *Community Dent Oral Epidemiol* 2008;36:237-248.

37. Ng SK, Leung WK. Oral health-related quality of life and periodontal status. *Community Dent Oral Epidemiol* 2006;34:114–122.

38. Lopez R, Baelum V. Oral health impact of periodontal diseases in adolescents. *J Dent Res* 2007;86:1105-1109.

39. Lawrence HP, Thomson WM, Broadbent JM, Poulton R. Oral health-related quality of life in a birth cohort of 32-year olds. *Community Dent Oral Epidemiol* 2008;36:305-316.

40. Mariño R, Schofield M, Wright C, Calache H, Minichiello V. Self-reported and clinically determined oral health status predictors for quality of life in dentate older migrant adults. *Community Dent Oral Epidemiol* 2008;36:85–94.

41. Jowett AK, Orr MT, Rawlinson A, Robinson PG. Psychosocial impact of periodontal disease and its treatment with 24-h root surface debridement. *J Clin Periodontol* 2009;36:413-418.

42. Bergström J, Preber H. Tobacco use as a risk factor. *J Periodontol* 1994;65:545-550.

43. Bergström J, Eliasson S, Dock J.Exposure to tobacco smoking and periodontal

health. *J Clin Periodontol* 2000;27:61-68.

44. Maida CA, Marcus M, Spolsky VW, Wang Y, Liu H. Socio-behavioral predictors of self-reported oral health-related quality of life. *Qual Life Res* 2013;22:559-566.

45. Klinge B, Norlund A. A socio-economic perspective on periodontal diseases – a systematic review. *J Clin Periodontol* 2005;32:314–325.

46. Bastos JL, Boing AF, Peres KG, Antunes JLF, Peres MA. Periodontal outcomes and social, racial and gender inequalities in Brazil: a systematic review of the literature between 1999 and 2008. *Cad Saúde Pública* 2011;27:141-153.

47. Gerritsen AE, Allen PF, Witter DJ, Bronkhorst EM, Creugers NHJ. Tooth loss and oral health-related quality of life: a systematic review and meta-analysis. *Health Qual Life Outcomes* 2010;8:126.

48. Albandar JM. Global risk factors and risk indicators for periodontal diseases. *Periodontol 2000* 2002;29:177-206.

49. Holland PW. Causal inference, path analysis and recursive structural equation models. *Sociol Methodol* 1988;18:449-484.

50. Beltrán-Aguilar ED, Eke PI, Thornton-Evans G, Petersen PE. Recording and surveillance systems for periodontal diseases. *Periodontol 2000* 2012;60:40-53.

Tables and Figures legends

Table 1. Descriptive characteristic of the sample (N=195).

Table 2. Fit indices for the confirmatory factor analysis of models

Table 3. Direct and indirect effects of the parsimonious structural equation model

Figure 1. Full theoretical model on the relationships between periodontal disease, tooth loss, individual and environmental characteristics and OHRQoL in adults with hypertension according to Wilson & Cleary conceptual model.[21]

Figure 2. Confirmatory factor analysis of the 2-factors 10 items (measurement model) obtained through bootstrap item loadings (SE/BC 95% CI).
Caption:
* Significant standardized coefficients (P<0.01).

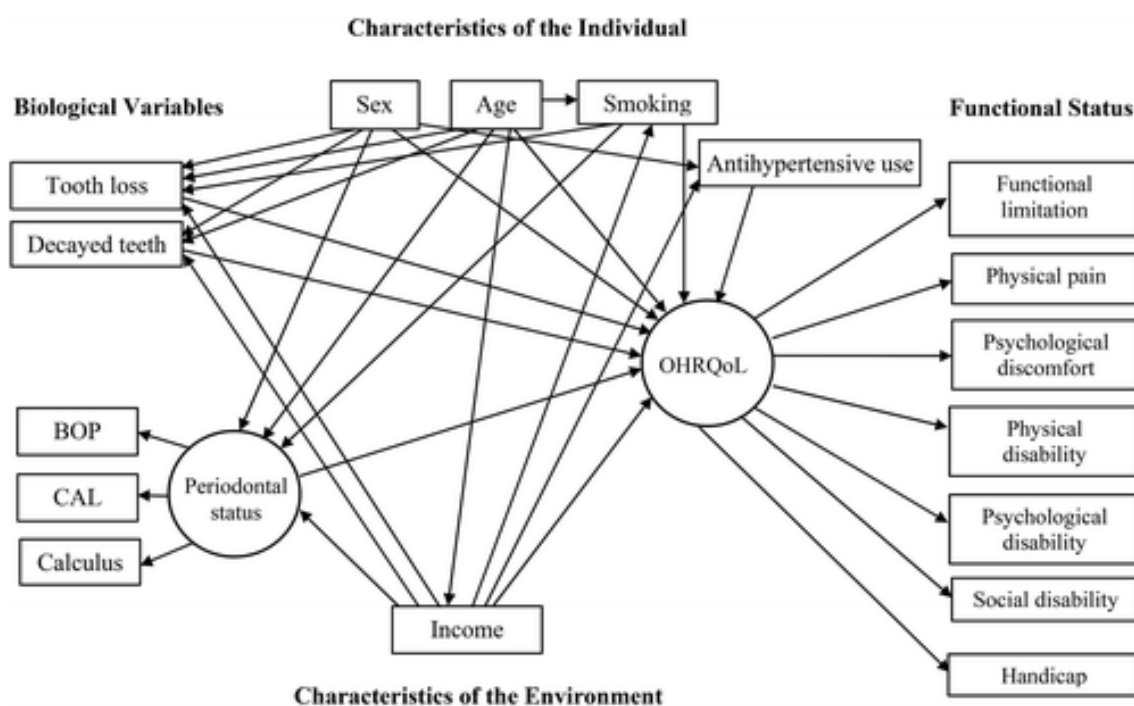Figure 3. Parsimonious model of associations between periodontal status, tooth loss, age, smoking, income and OHRQoL.

Caption:
* Significant standardized coefficients (P<0.05).
† Significant standardized coefficients (P<0.01).
Direct effects are indicated by solid lines.
Indirect effects are indicated by dashed lines.

Characteristics of the Individual

Biological Variables — Sex, Age, Smoking — Functional Status

Tooth loss, Decayed teeth, Antihypertensive use, OHRQoL, Functional limitation, Physical pain, Psychological discomfort, Physical disability, Psychological disability, Social disability, Handicap

BOP, CAL, Calculus — Periodontal status

Income

Characteristics of the Environment
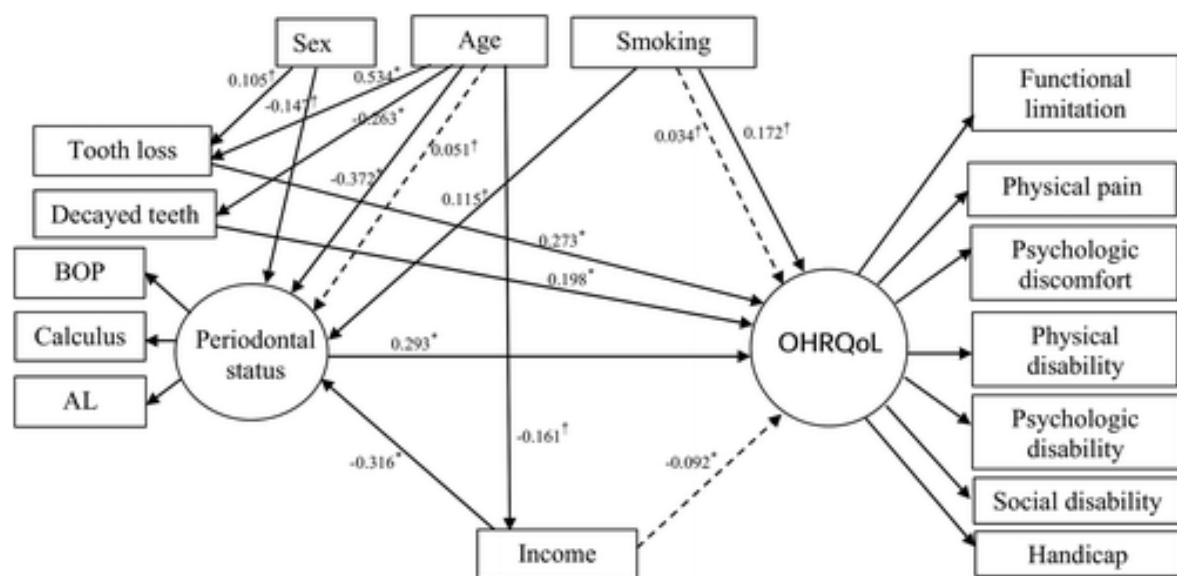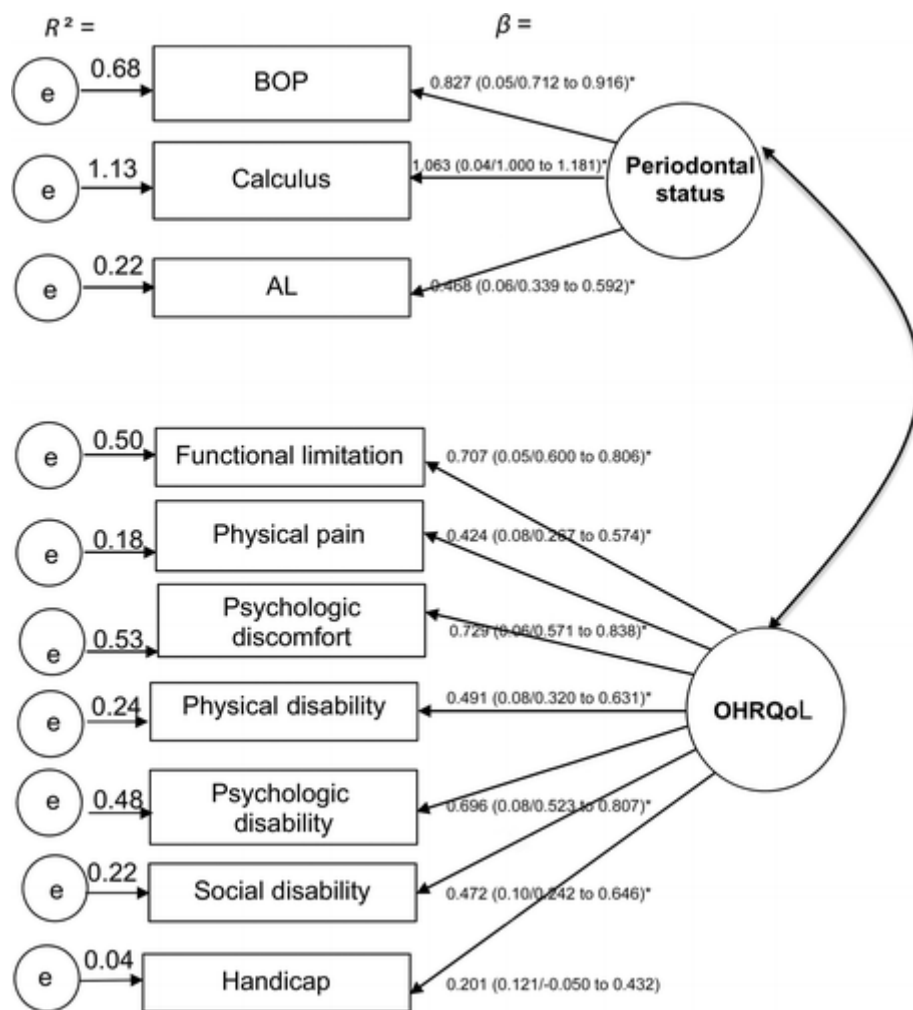
Table 1. Descriptive characteristic of the sample (N=195).

Variable	Mean/N	SD/%	Range
Age, mean (SD)	55.7	13.9	23-83
Sex, N (%)			
Female	132	67.7	-
Male	63	32.3	-
Monthly family income (R$), N (%)			
≤ 250	38	19.5	-
251-500	45	23.1	-
501-1500	66	33.8	-
≥ 1500	46	23.6	-
Smoking, N (%)		75.4	-
Non-smokers	50	25.6	-
Smoking initiation			
< 15years-old	95	48.7	-
15-16 years-old	23	11.8	-
17-19 years-old	10	5.1	-
≥ 20 years-old	17	8.7	-
Duration of hypertension (years), mean (SD)	6.17	5.4	0-25
Tooth loss, mean (SD)	20.3	10.8	1-32
Decayed teeth, mean (SD)	2.3	4.3	0-27
Periodontal status			
BOP ≥ 1 sextant, N (%)	86	44.1	
Calculus ≥ 1 sextant, N (%)	92	47.2	
AL, N of sextants (%)			
0 - 3 mm	340	29.1	
4 – 5 mm	123	10.5	
6 – 8 mm	26	2.2	
9 – 11 mm	7	0.6	
12+ mm	2	0.2	
Excluded	672	57.4	
OHRQoL (OHIP), mean (SD)	9.4	9.4	0-46
OHIP Functional limitation	1.6	2.4	0-8
OHIP Physical pain	2.1	2.7	0-8
OHIP Psychological discomfort	2.3	2.6	0-8
OHIP Physical disability	1.5	2.6	0-8
OHIP Social disability	0.2	1.3	0-8
OHIP Handicap	0.2	1.0	0-6

Table 2. Fit indices for the confirmatory factor analysis of models

Model	χ^2/df ratio	GFI	CFI	SRMR	RMSEA
Full	1.585	0.920	0.953	0.060	0.055
Measurement model	1.661	0.926	0.953	0.065	0.058
Parsimonious	1.556	0.922	0.954	0.067	0.054

Chi-square difference between full model and parsimonious model was 61.996 (df=90) was not statistically significant (P=0.989).

Table 3. Direct and indirect effects of the parsimonious structural equation model

Parameter	β	Bootstrap SE	Bias-corrected 95% CI
Direct effects			
Sex – tooth loss	0.105	0.052	0.002 / 0.205*
Sex – periodontal status	-0.147	0.068	-0.290 / -0.015*
Age – income	-0.161	0.072	-0.308 / -0.022*
Age – tooth loss	0.534	0.052	0.425 / 0.632[†]
Age – decayed teeth	-0.263	0.074	-0.392 / - 0.092[†]
Age - periodontal status	-0.372	0.058	-0.480 / -0.259[†]
Smoking - periodontal status	0.115	0.059	0.004 / 0.238*
Smoking – OHRQoL	0.172	0.077	0.025/0.317*
Income - periodontal status	-0.316	0.064	-0.438 / -0.186[†]
Tooth loss - OHRQoL	0.273	0.079	0.092 / 0.406[†]
Decayed teeth - OHRQoL	0.198	0.065	0.059 / 0.317[†]
Periodontal status - OHRQoL	0.293	0.108	0.079 / 0.499[†]
Indirects effects			
Age - periodontal status	0.051	0.026	0.007 / 0.116*
Smoking – OHRQoL	0.034	0.022	0.003 / 0.096*
Income – OHRQoL	-0.092	0.042	-0.192 / -0.025[†]

* $P < 0.05$, †$P < 0.01$