Article:

Valente, M.I.B. and Vettore, M.V. orcid.org/0000-0001-6299-4432 (2017) Contextual and individual determinants of periodontal disease: Multilevel analysis based on Andersen's model. Community Dentistry and Oral Epidemiology, 46 (2). pp. 161-168. ISSN 0301-5661

https://doi.org/10.1111/cdoe.12349

Contextual and individual determinants of periodontal disease: multi-level analysis based on Andersen's model

Running title: Contextual predictors of periodontitis

Authors:

Maria Isabel Bastos Valente[1,2] *

Mario Vianna Vettore[1]

[1] Unit of Dental Public Health, School of Clinical Dentistry, University of Sheffield, UK

[2] Department of Specific Formation, School of Dentistry, Fluminense Federal University, Nova Friburgo, RJ, Brazil

*** Corresponding Author**

Address: Department of Specific Formation, School of Dentistry, Fluminense Federal University, Nova Friburgo, RJ, Brazil

R. Dr. Silvio Henrique Braune, 22, Nova Friburgo - RJ, 28625-650, Brazil

Phone: +55 22 2528-7168 E-mail: belvalente@hotmail.com

Conflict of interest and source of funding statement

The authors declare no conflict of interest. Maria Isabel Bastos Valente was supported by a fellowship from CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico), Ministry of Science, Technology and Innovation of Brazil.

Key words: Periodontal diseases, Multilevel analysis, Social determinants of health, Adults, Elderly people.

ABSTRACT

Aim: To investigate the relationship of contextual and individual factors with periodontal disease in dentate adults and older people using the Andersen's behavioural model.

Methods: Secondary individual data from 6011 adults and 2369 older people from the Brazilian Oral Health Survey (2010) were combined with contextual data for 27 cities. Attachment loss (AL) categories for each sextant were coded and summed to obtain the periodontal disease measure. The association of predisposing, enabling and need characteristics at city and individual-level with periodontal disease was assessed using an adapted version of the Andersen's behavioural model. Multilevel Poisson regression was used to estimate rate ratios (RR) and 95% CIs.

Results: Periodontal disease was associated with contextual predisposing (RR 0.93; 95% CI=0.87-0.99) and enabling factors (RR 0.99; 95% CI=0.98-0.99) in adults. Contextual predisposing was also associated with periodontal disease in older people (RR 0.82; 95% CI=0.73-0.92). Individual predisposing (age, sex and schooling) and need characteristics (perceived treatment need) were common predictors of periodontal disease in adults and older people. Periodontal disease was also associated with behaviours in the latter age group.

Conclusion: Contextual predisposing factors and individual characteristics influenced periodontal disease experience in adults and older people. Contextual enabling factors were also meaningful determinants of periodontal disease in the former age group.

Introduction

Periodontitis is considered the sixth-most prevalent disease in the world, with an estimated global prevalence of 11.2% in the adult population[1]. Previous studies on risk for periodontal diseases have been focused on individual sociodemographic characteristics, behaviours, psychosocial factors, systemic conditions, and microbiological and genetic factors[2,3]. However, the individual risk approach to the aetiology of periodontal diseases ignores the role of social and political contexts in people's health, and these are strongly associated with oral health inequalities[4]. Living and social conditions, wealth distribution and health policies are important aspects of the distribution of diseases, suggesting investigating the determinants of periodontal diseases should not be limited to individual factors[5]

Evidence suggests that periodontal diseases are unevenly distributed across population groups, and living in unequal societies may be associated with a higher likelihood of periodontal disease experience[6-9]. To date, investigations of the possible contextual determinants of periodontal disease are scarce, and previous studies on this topic have addressed specific contextual factors and were not guided by a robust theoretical framework[2,6,8,10].

The adoption of a theoretical model in social oral epidemiology facilitates the understanding of the study's rationale and the interpretation of the findings. In the present research, a theoretical framework was adapted from Andersen's behavioural model to test the relationship of contextual and individual determinants with periodontal disease, as proposed by Thomson and coworkers[11]. According to this model, complex contextual and health-system factors influence periodontal status through personal characteristics[12]. The model is comprises contextual and individual-level predisposing, enabling and need components that influence health.[12]

Brazil is the largest South-American country, characterised by historic and remarkable social inequalities and marked by regional inequalities in the distribution of periodontal diseases. The aim of this study was to investigate the association of contextual and individual factors with periodontal disease in adults and older people using an adapted version of Andersen's behavioural model

Methods

The present study combined individual-level secondary data from the Brazilian Oral Health Survey (SBBrasil Project)[13] and city-level contextual characteristics. The SBBrasil Project was a nationwide survey conducted in 2010 in the urban areas in Brazil. The sample was obtained through multiple-stage probabilistic sampling and was representative of the 27 cities (domains) referring to the state capitals and the Federal District. First, the census tracts were selected in the cities (primary sampling units). Individuals were selected from the census tracts in the second sampling stage process. The sample was considered to be representative of oral health conditions for state capitals and the Federal District. Detailed information on the sampling can be found in Silvia and Roncalli[14].

The studied population included adults aged 35-44 years and older people aged 65-74 years from the state Capitals and the Federal District. Edentulous (missing all natural teeth) participants, those living in the interior municipalities and those without complete data were excluded.

Individual characteristics were obtained using a structured questionnaire through individual interviews. Dental examinations were carried out in accordance with the World Health Organization protocol of oral health surveys[15]. The interviews and dental examinations were performed by trained assistants and calibrated dentists, respectively, from the Brazilian Health Care System (Sistema Único de Saúde) at the participants' home.

Before data collection, inter-examiner reliability for dental examinations was evaluated following the consensus technique involving 10 dentists in each state capital and the Federal District. The minimum weighted kappa coefficient of 0.65 was required. Dentists who did not reach this value were excluded or replaced[15].

Periodontal examinations were conducted using a ball-end CPI probe to determine attachment loss (AL) for each sextant according to the following categories: 0-3mm, 4-5mm, 6-8mm, 9-11mm and ≥12mm (and excluded)[15]. AL represents the cumulative experience of periodontal disease over time and is considered the most appropriate periodontal measure[16]. The original categories of AL were coded as follows: excluded sextant = 0, 0-3mm = 1.5mm, 4-5mm = 4.5mm, 6-8mm = 7mm, 9-11mm = 10mm and ≥12mm = 12mm. The codes were then summed to obtain a final AL score, namely Accumulated Attachment Loss (AAL) for each person. The AAL score ranges from 1.5 to 72. Additional information on the AAL score is available in the online Appendix 1. The number of teeth was assessed according to the number of sound, decayed and filled natural teeth (including third molars).

Individual predisposing variables included age, sex, skin colour and educational level. Self-perceived skin colour was assessed according to the following categories: white, brown, black, yellow or indigenous. Participants of yellow and indigenous skin colour were grouped as others due to their low occurrence. Educational level was evaluated based on the number of concluded years of schooling. Enabling individual variables were per capita monthly income, type of dental services used (public or private). The original categories of monthly family income (≤ R$ 250; R$251-500; R$501-1500; R$1501-2500; R$ 2501-4500; R$4501-9500; > R$9500) was used to estimate the per capita monthly income according to the methodology described by Celeste and Bastos[17]. Perceived dental treatment needs (yes or no) and the Oral Impacts on Daily Performance (OIDP) were employed to assess individual needs[18]. The OIDP was developed to assess population dental needs along with dental indices and normative measures with respect to facilitate dental service planning[18]. OIDP scores were recorded based on the presence or absence of each impact, resulting in a final score from 0 to 8. Health behaviours were assessed according to the frequency and pattern of use of dental services, including time since the last dental visit (< 1 year; 1 to 2 years; > 2 years) and reason for last dental attendance (check-up for preventive purposes, such as fluoride application; dental treatment for non-emergency and no severe dental problems, such as dental filling; emergency dental care due to dental pain, such as pulpal inflammation; and dental extraction for severe dental problems, such as extensive dental caries).

Contextual factors were based on the domains of Andersen's model. Indicators of contextual predisposing characteristics were income inequality (Gini index), Human Development Index (HDI) and Life Expectancy index in 2010, obtained from the Brazilian agency of United Nations Development Program[19]. The Gini index evaluates income inequality where scores vary from 0 to 1. The higher the score, the greater the income inequality. HDI index is a composite index to assess social deprivation. The HDI score ranges from 0 to 1 and the higher the value the better the social development. The life expectancy index is the average number of years that persons are expected to live from birth, if the mortality pattern remains stable across all age groups throughout life. The contextual enabling characteristics indicators were dentists/population ratio (D/P Ratio)[20], population coverage by primary health care (PHC coverage), integration of oral health care teams into primary care (OHT/PHC) in 2010[21]. Contextual need characteristics used the proportion of adults with diabetes and proportion of adult smokers in 2010[22]. Further details of the concepts and measures of Andersen's behavioural model to test the relationship of contextual and individual determinants with periodontal disease are available in online Appendix 2.

Substantial correlations were observed between the contextual variables of each dimension of Ansersen's model. Spearman coefficients were used to highlight the direction and strength of the correlations as follows: (i) Predisposing contextual variables: Gini index and HDI (rho = -0.248), Gini index and life expectancy index (rho = -0.182), HDI and life expectancy index (rho = 0.917); (ii) Enabling contextual variables: D/P Ratio and PHC coverage (rho = 0.403), D/P Ratio and OHT/PHC (rho = 0.160), PHC coverage and OHT/PHC (rho = 0.694); (iii) Contextual need variables: proportion of adults with diabetes and proportion of adult smokers (rho = 0.338). Principal Component Analysis (PCA) was performed to test the contextual variables of each theoretical dimension of the Andersen's model. Two factors were obtained based on the following criteria: correlations between contextual indicators >0.4, eigenvalues >1, component loadings >0.65, Kaiser-Meyer-Olkin (KMO) value >0.700 and $P<0.05$ of Bartlett's test of sphericity. The two factors explained 92% of the total variance and indicated contextual predisposing and enabling characteristics. The former was composed by HDI (loading coeff = 0.693) and life expectancy index (loading coeff = 0.692) while the latter included PHC coverage (loading coeff = 0.706) and OHT/PHC (loading coeff = 0.705). Both variables related to contextual needs were considered in separate in the analysis.

Individual characteristics, periodontal AL measures and number of teeth were described through proportions and means with respective 95% confidence intervals (CIs), by age group. The multilevel structure of analysis included 6011 adults and 2369 older people (level 1) grouped into 27 cities (level 2). Multilevel Poisson regression was used to test the association of contextual and individual independent variables with AAL separately for adults and elderly people. Variables with $P<0.05$ were considered for the multivariable analysis.

The outcome variable (AAL) was not normally distributed as P-values of the Shapiro-Wilk Test for adults and elderly people were 0.014 and <0.001, respectively. Thus, multilevel Poisson multivariable analysis was the technique employed to examine simultaneously the effect of different predictors including contextual effects of city-level variables by accounting for spatial clustering of participants within areas. A two-level random intercepts and fixed-slopes model structure with individuals nested within cities was fitted to estimate the rate ratios (RR) and 95% CIs, indicating the likelihood of having a higher mean of AAL. The overdispersion of the data was handled through using a two-level random intercept model.

Stepwise forward selection of variables in five models was conducted to obtain a parcimonious final model for adults and elderly people, according to the theoretical framework

(Figure 1). The first model consisted of contextual predisposing and enabling factors. The second and third models included individual predisposing and enabling variables. The final models included individual need and behaviours. Variables that remained statistically significant at 5% (P≤0.05) were retained in the analysis for adjustment in the next model. After estimating each model, statistically non-significant variables were removed to generate a statistically parsimonious model. Detailed explanation of multilevel analysis is available in the online Appendix 3. The statistical analyses were conducted using STATA 14.0 (College Station, TX USA) with sampling weights used in all analyses.

The SBBrasil 2010 Project was approved by the Brazilian National Council of Ethics in Research (Protocol No. 15498).

Results

Initially, 7333 adults and 6003 older people living in the state capitals and the Federal District were invited to participate in the SBBrasil Project. Of these, 7173 adults (response rate = 97.8%) and 5915 older people (response rate = 95.8%) were examined and interviewed. First, edentulous adults (N = 162) and older people (N = 2651) were excluded. Then, adults (N = 1000) and older people (N = 895) with missing data in one or more variables were excluded. The final sample was 6011 adults and 2369 older people nested in 27 cities. Descriptive characteristics of all adults and older people in the SBBrasil Project and the study sample are presented in online Appendix 4. Periodontal measures and number of teeth in adults, and mean age, AAL and number of teeth in older people were significantly different between the study sample and the full sample.

Individual characteristics, periodontal measures and number of teeth are presented in Table 1 according to age groups. The mean age of the adults and older people was 39.3 and 68.7 years, respectively. Most participants were females and had white skin colour. Adults were more schooled but had lower per capita income than older people. Most participants reported dental treatment needs, visiting a dentist in the last year and visited a dentist for treatment reasons. The prevalence of sextants with CAL ≥ 4mm was 24% in adults and 48.1% in older people. The number of teeth in latter age group was much lower than in the former (Table 1). The mean of AAL according to the low, moderate and high levels of the contextual variables is presented in online Appendix 5.

Unadjusted analyses are presented in Table 2. Contextual predisposing factors were associated with AAL in adults and elderly people. All individual predisposing, enabling, needs and behaviours variables were associated with AAL in adults. Individual predisposing, per capita monthly income (enabling), dental treatment needs (needs) and behavioural variables were also associated with AAL in older people.

Table 3 presents the multilevel Poisson regression models for adults. In model 1, contextual predisposing and enabling factors were inversely associated with AAL. Individual predisposing characteristics including age, sex and schooling in Model 2 were associated with AAL and remained associated with AAL afterwards. The mean AAL was significantly higher for adults with higher levels of oral impacts and perceived dental treatment need in Model 4. In the final model (Model 5), adults living in the cities with greater levels of contextual predisposing (RR=0.93; 95% CI 0.87-0.99) and enabling factors (RR=0.99; 95% CI 0.98-0.99) were less likely to have a higher mean AAL. In addition, higher age, being males, lower schooling, higher OIDP, and dental treatment needs remained associated with AAL.

The association between contextual and individual variables with AAL in older people is summarised in Table 4. Older people in the cities with higher levels of predisposing factors were less likely to have a higher mean AAL in Model 1. All individual predisposing variables were associated with AAL in Model 2. Per capita monthly income in Model 3 and treatment needs in Model 4 was associated with a higher mean AAL. In the final model (Model 5), the mean AAL was lower among older people from cities with high levels of contextual predisposing factors (RR=0.82; 95% CI 0.73-0.92). Higher age, being female, or having a lower per capita monthly income were associated with lower mean AAL. Skin colour, treatment needs and behaviours remained associated with AAL.

Discussion

In this study, periodontal disease experience was associated with predisposing contextual factors in adults and older people. In addition, enabling contextual factors were associated with periodontal disease in the former age group. Individual predisposing characteristics were also associated with periodontal disease in adults and older people, and enabling factors were associated with periodontal disease in the latter age group. These findings highlight the importance of the contextual and individual factors in the occurrence of periodontal disease according to Andersen’s framework.

Our findings are in agreement with those from previous studies on the relationship between area-level social inequalities and poor oral health[23]. Contextual social determinants were associated with dental caries, tooth loss, dental treatment needs and oral health-related quality of life in adults and elderly people[24-27]. Furthermore, previous research reported the influence of contextual determinants on periodontal disease[2,6,8-10]. One study did not find an association between income inequality and periodontal disease in adults[28]. Previous research on social inequalities and periodontal disease among older people is scarce.

Most previous studies on the relationship between social inequalities and oral health have evaluated few contextual factors. However, broader determinants of oral diseases encompass a range of environmental causes, including social conditions, organisation of health care and public policies. To our knowledge, this is the first study using the adapted version of Andersen's framework to investigate the association of environmental determinants and individual characteristics with periodontal disease[11]. The positive aspect of using Andersen's model in the present study is the rationale to select the contextual and individual factors. However, the operationalisation of Andersen's model was challenging because some of the components are broadly defined. In addition, it is always difficult to select independent variables to properly reflect a theoretical model when the study is based on secondary data analysis. The amount of collinearity between contextual variables in each dimension of Andersen's model suggested that they were adequate. Nevertheless, a contextual factor for needs characteristic was not identified through principal component analysis, probably because of the inadequacy of the contextual variables selected. Overall, our findings partially support the use of Andersen's behavioural model in the identification of contextual and individual predictors of periodontal disease[12].

The association between contextual predisposing factors and AAL reinforces the role of social inequalities in periodontal disease[6,8,9]. This finding also highlights that contextual social factors are a multifaceted and historical phenomenon in population oral health. The current emphasis placed upon the behavioural factors of oral inequalities should be replaced by a more comprehensive approach encompassing the distal determinants of oral health[29]. Contextual enabling factors were also associated with AAL in adults. The relationship between lower integration of dentists into primary health care and periodontal disease has been shown[8]. The replacement of traditional dental services by oral health care models that integrate dentists and other health professionals has the potential to reduce oral health inequalities through health promotion strategies[30].

Some limitations of this study should be addressed. The cross-sectional data restrict causal inferences and a substantial proportion of adults and older people were excluded from the analyses due to missing data. In addition, the studied sample is from urban areas of the Brazilian state capitals and the findings should not be generalised to other populations. The occurrence of periodontal disease was possibly underestimated in the study because of the use of a partial recording protocol to measure AL[31]. The exclusion of edentulous participants may have affected the representativeness of the different socioeconomic groups, since tooth loss and edentulism are strongly associated with to socioeconomic status[28]. The association of contextual and individual characteristics with periodontal disease are not adjusted for individual smoking, diabetes and oral hygiene since this information were not available. Thus confounding bias might have overestimated some of the reported associations.

There is no consensus in measuring periodontal disease in epidemiological studies, since different periodontal clinical parameters and cut-offs of periodontal measures have been proposed[32-34]. In this study, periodontal disease was assessed according to the experience of destructive periodontal disease throughout life since the theoretical model involved long-term determinants. The advantage of this approach is to capture the lifetime accumulated destruction of the periodontal disease represented by attachment loss. Nevertheless, the use of additional periodontal measures would provide a more comprehensive assessment of the periodontal status[16]. The severity of AL may be sustained by complex interaction between individual and contextual-level predisposing, enabling and need characteristics, which operational pathways may vary according to age, cohort effect and developmental trajectory[35].

The older population in Brazil has been increasing between 2 and 4% per year. This will result in approximately 19% of the population in 2050 being at least 65 years old[36]. Monitoring trends in socioeconomic inequality in periodontal disease in adults and older people is essential to underpin the public policies to tackle the oral health care needs of different population groups. The social determinants of oral health inequalities and the common risk factor approach should be on the agenda of policy makers and health care workers. The strategies should not be only addressed to individual factors. Health promoting strategies and inter-sectoral public policies focusing on social development through improvements in education standards and reduction of income inequality, as well as the expansion of primary health care and greater integration of oral health care professionals into primary care, are essential to reduce social inequalities in periodontal disease. The understanding of the specific pathways on the influence of contextual and individual factors on periodontal disease remains unclear. Further longitudinal studies using Andersen's behavioural model are needed to clarify the behavioural and other individual mechanisms by which contextual and individual social determinants influence periodontal disease. Future research should also evaluate the role of social inequalities on periodontal disease in rural populations.

Conclusions

Andersen’s behavioural model was a useful framework to evaluate the contextual and individual influences on periodontal disease in adults and older people. Predisposing contextual factors and individual characteristics were of greater relevance for periodontal disease in both age groups. Enabling contextual factors were also important for periodontal disease occurrence among adults.

References

1. Kassebaum NJ, Bernabe 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.
2. Hobdell MH, Oliveira ER, Bautista R, et al. Oral diseases and socio-economic status (SES). Br Dent J 2003;194:91-96.
3. Genco RJ, Borgnakke WS. Risk factors for periodontal disease. Periodontol 2000 2013;62:59-94.
4. Marmot M, Bell R. Social determinants and dental health. Adv Dent Res. 2011;23:201-206.
5. Newton JT, Bower EJ. The social determinants of oral health: new approaches to conceptualizing and researching complex causal networks. Community Dent Oral Epidemiol 2005;33:25-34.
6. Sabbah W, Sheiham A, Bernabe E. Income inequality and periodontal diseases in rich countries: an ecological cross-sectional study. Int Dent J 2010;60:370-374.
7. Borrell LN, Burt BA, Warren RC, Neighbors HW. The role of individual and neighborhood social factors on periodontitis: the third National Health and Nutrition Examination Survey. J Periodontol 2006;77:444-453.
8. Vettore MV, Marques RADA, Peres MA. Desigualdades sociais e doenca periodontal no estudo SBBrasil 2010: abordagem multinivel. Rev Saúde Pública 2013;47:29-39.
9. Dalazen CE, De Carli AD, Bomfim RA, Santos ML. Contextual and Individual Factors Influencing Periodontal Treatment Needs by Elderly Brazilians: A Multilevel Analysis. PLoS One 2016;11:e0156231.
10. Borrell LN, Crawford ND. Socioeconomic position indicators and periodontitis: examining the evidence. Periodontol 2000 2012;58:69-83.

11. Thomson WM, Sheiham A, Spencer AJ. Sociobehavioral aspects of periodontal disease. Periodontol 2000 2012;60:54-63.
12. Andersen RM. National health surveys and the behavioral model of health services use. Med Care 2008;46:647-653.
13. Roncalli AG, Silva NND, Nascimento AC, et al. Aspectos metodológicos do Projeto SBBrasil 2010 de interesse para inquéritos nacionais de saúde. Cad Saúde Pública 2012;28:s40-s57.
14. Silva NND, Roncalli AG. Sampling plan, weighting process and design effects of the Brazilian Oral Health Survey. Rev Saúde Pública 2013;47(Suppl 3):1-8.
15. WHO. Oral Health Surveys, Basic Methods, 4th edn. Geneva: World Health Organization; 1997.
16. Tonetti MS, Claffey N. Advances in the progression of periodontitis and proposal of definitions of a periodontitis case and disease progression for use in risk factor research: Group C Consensus report of the 5th European workshop in periodontology. J Clin Periodontol 2005;32:210-213.
17. Celeste RK, Bastos JL. Mid-point for open-ended income category and the effect of equivalence scales on the income-health relationship. Rev Saúde Pública 2013;47(Suppl 3):168-171.
18. Adulyanon S, Vourapukjaru J, Sheiham A. Oral impacts affecting daily performance in a low dental disease Thai population. Community Dent Oral Epidemiol 1996;24:385-389.
19. UNDP. Brazilian agency of United Nations Development Program. Programa das Nações Unidas para o Desenvolvimento. Atlas do desenvolvimento humanos dos municípios; 2013. http://www.atlasbrasil.org.br/2013/. Accessed 25 February 2016.
20. CNES. Cadastro Nacional de estabelecimentos de saúde. Família CBO; 2016. http://cnes2.datasus.gov.br/Mod_Ind_Profissional_com_CBO.asp. Accessed 02 February 2016.
21. DAB/SAS/MS. Brasil. Ministério da Saúde. Secretaria de Atenção a Saúde. Departamento de Atenção Básica. Coberturas do Saúde da Família; 2015. http://dab.saude.gov.br/dab/historico_cobertura_ sf/historico_cobertura_sf_relatorio.php. Accessed 26 August 2015.
22. Brasil. Vigitel Brasil 2014: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico. Brasília: Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de Vigilância de Doenças e Agravos não Transmissíveis e Promoção da Saúde; 2015.

23. Singh A, Harford J, Schuch HS, Watt RG, Peres MA. Theoretical basis and explanation for the relationship between area-level social inequalities and population oral health outcomes – A scoping review. SSM - Population Health 2016;2:451-462.
24. Bernabe E, Sheiham A, Sabbah W. Income, income inequality, dental caries and dental care levels: an ecological study in rich countries. Caries Res 2009;43:294-301.
25. Roncalli AG, Tsakos G, Sheiham A, de Souza GC, Watt RG. Social determinants of dental treatment needs in Brazilian adults. BMC Public Health 2014;14:1097.
26. Goulart MdeA, Vettore MV. Is the relative increase in income inequality related to tooth loss in middle-aged adults? J Public Health Dent 2016;76:65-75.
27. Vettore MV, Aqeeli A. The roles of contextual and individual social determinants of oral health-related quality of life in Brazilian adults. Qual Life Res 2016;25:1029-42.
28. Celeste RK, Fritzell J, Nadanovsky P. The relationship between levels of income inequality and dental caries and periodontal diseases. Cad Saude Publica 2011;27:1111-1120.
29. Baelum V, Lopez R. Periodontal epidemiology: towards social science or molecular biology? Community Dent Oral Epidemiol 2004;32:239-49.
30. Sheiham A, Alexander D, Cohen L, et al. Global oral health inequalities: task group--implementation and delivery of oral health strategies. Adv Dent Res 2011;23:259-267.
31. Peres MA, Peres KG, Cascaes AM, et al. Validity of partial protocols to assess the prevalence of periodontal outcomes and associated sociodemographic and behavior factors in adolescents and young adults. J Periodontol 2012;83:369-378.
32. Page RC, Eke PI. Case definitions for use in population-based surveillance of periodontitis. J Periodontol 2007;78:1387-1399.
33. American Academy of Periodontology. American Academy of Periodontology Task Force Report on the Update to the 1999 Classification of Periodontal Diseases and Conditions. J Periodontol 2015;86:835-838.
34. López R, Baelum V. Periodontal disease classifications revisited. Eur J Oral Sci 2015;123:385-389.
35. Guarnizo-Herreño CC, Watt RG, Fuller E, et al. Socioeconomic position and subjective oral health: findings for the adult population in England, Wales and Northern Ireland. BMC Public Health 2014;14:1-9.
36. Carvalho JAM, Rodríguez-Wong LL. A transição da estrutura etária da população brasileira na primeira metade do século XXI. Cad. Saúde Pública 2008;24:597-605.

Table 1. Individual predisposing, enabling and need characteristics, health behaviours, periodontal measures and number of teeth in adults and elderly people.

Variable	Adults (N = 6011) Mean/% (95% CI)	Elderly people (N =2369) Mean/% (95% CI)
Predisposing		
Age, mean	39.3 (39.2-39.4)	68.7 (68.4-68.8)
Sex, %		
Male	28.6 (25.4-32.1)	37.2 (34.2-40.4)
Female	71.4 (67.9-74.6)	62.8 (59.6-65.8)
Skin colour, %		
White	47.2 (43.6-50.8)	53.4 (48.8-58.0)
Brown	39.6 (35.7-43.6)	28.5 (23.1-34.4)
Black	11.4 (9.7-13.4)	16.5 (10.5-24.8)
Others	1.8 (1.1-2.9)	1.7 (0.9-3.0)
Years of schooling, mean	8.9 (8.4-9.6)	6.6 (6.1-7.2)
Enabling		
Per capita monthly income (R$), mean	596.8 (528.0-665.5)	989.9 (834.6-1143.3)
Type of dental services, %		
Public	33.0 (29.0-37.3)	25.7 (22.3-29.5)
Private	67.0 (62.7-71.0)	74.3 (70.5-77.7)
Needs		
OIDP, mean	1.7 (1.4-2.0)	1.3 (1.2-1.4)
Dental treatment needs, %		
Yes	79.5 (75.2-83.2)	65.7 (60.8-70.2)
No	20.5 (16.8-24.8)	34.3 (29.8-39.2)
Behaviours		
Time since last dental visit, %		
< 1 year	50.5 (46.1-54.9)	43.9 (39.3-48.5)
1-2 years	25.7 (23.0-28.5)	24.7 (20.8-29.1)
> 2 years	23.8 (20.1-28.0)	31.4 (24.9-38.7)
Reason for last dental visit, %		
Maintenance	23.9 (21.7-26.3)	16.5 (13.1-20.5)
Treatment	45.3 (42.4-48.2)	47.8 (42.4-53.4)
Pain	15.7 (12.8-19.1)	13.3 (9.4-18.5)
Extraction	15.1 (13.3-17.2)	22.3 (18.1-27.2)
Periodontal measures and number of teeth		
Accumulated attachment loss, mean	8.7 (8.4-9.1)	6.9 (5.8-8.0)
CAL number of sextants, %		
0-3mm	76.0 (72.4-79.3)	51.9 (42.2-61.5)
4-5mm	17.4 (15.0-20.0)	34.1 (25.3-44.2)
6-8mm	4.8 (3.4-6.6)	11.3 (7.8-16.1)
9-11mm	1.2 (0.7-2.2)	1.1 (0.5-2.2)
>12	0.6 (0.3-1.3)	1.6 (0.5-5.0)
Number of teeth, mean	24.0 (23.6-24.2)	13.2 (12.3-14.1)

Table 2. Unadjusted association of contextual and individual characteristics with accumulated attachment loss, according to age group.

Contextual Variables	Adults (N = 6011)			Elderly people (N = 2369)		
	Variance†	RR‡	95% CI	Variance†	RR‡	95% CI
Predisposing	0.110 (0.016)*	0.93	0.87-0.99*	0.168 (0.024)*	0.85	0.76-0.95*
Enabling	0.111 (0.016)*	0.99	0.99-1.00	0.190 (0.027)*	1.00	0.99-1.01
Need						
% diabetics (2007)	0.118 (0.017)*	1.00	0.96-1.04	0.192 (0.027)*	1.02	0.96-1.09
% smokers (2007)	0.117 (0.017)*	1.01	0.99-1.02	0.187 (0.027)*	1.02	0.99-1.05
Individual Variables						
Predisposing						
Age		1.01	1.01-1.01*		0.99	0.98-0.99*
Sex						
Male		1.00			1.00	
Female		0.92	0.90-0.93*		0.76	0.74-0.78*
Skin colour						
White		1.00			1.00	
Brown		1.02	1.01-1.05*		1.04	1.01-1.08*
Black		1.03	0.99-1.06		1.11	1.06-1.17*
Others		1.00	0.94-1.06		1.04	0.94-1.16
Years of schooling		0.99	0.98-0.99*		1.01	1.01-1.01*
Enabling						
Per capita monthly income		0.99	0.99-0.99*		1.01	1.01-1.01*
Type of dental services						
Private		1.00			1.00	
Public		1.03	1.01-1.05*		1.01	0.98-1.05
Need						
OIDP		1.01	1.01-1.02*		1.01	0.99-1.01
Dental treatment needs						
No		1.00			1.00	
Yes		1.11	1.09-1.14*		1.11	1.07-1.15*
Behaviours						
Time since last dental visit						
< 1 year		1.00			1.00	
1-2 years		1.02	1.01-1.04*		1.01	0.98-1.05
> 2 years		1.05	1.02-1.07*		1.04	1.01-1.08*
Reason for last dental visit						
Check-up		1.00			1.00	
Treatment		1.04	1.02-1.07*		0.96	0.93-1.01
Dental pain		1.07	1.04-1.10*		1.10	1.04-1.16*
Extraction		1.04	1.02-1.08*		1.05	1.01-1.10*

† Variance at the city level [Ωμ (standard error)] was obtained through random effects
‡ RR rate ratio
* P ≤ 0.05

Table 3. Adjusted association of contextual and individual variables with accumulated attachment loss in adults using multilevel Poisson regression.

Variables	Model 1 RR[a] (95% CI)	Model 2 RR[a] (95% CI)	Model 3 RR[a] (95% CI)	Model 4 RR[a] (95% CI)	Model 5 RR[a] (95% CI)
Contextual Variables					
Predisposing	0.94 (0.87-0.99)[b]	0.93 (0.87-0.99)[b]	0.93 (0.86-0.99)[b]	0.93 (0.86-0.99)[b]	0.93 (0.87-0.99)[b]
Enabling	0.99 (0.99-0.99)[b]	0.99 (0.98-0.99)[b]	0.99 (0.98-0.99)[b]	0.99 (0.98-0.99)[b]	0.99 (0.98-0.99)[b]
Individual Variables					
Predisposing					
Age		1.01 (1.01-1.01)[c]	1.01 (1.01-1.02)[c]	1.01 (1.01-1.01)[c]	1.01 (1.01-1.01)[c]
Sex					
Male		1.00	1.00	1.00	1.00
Female		0.92 (0.90-0.93)[c]	0.92 (0.90-0.93)[c]	0.91 (0.90-0.93)[c]	0.91 (0.90-0.93)[c]
Skin colour					
White		1.00			
Brown		1.02 (0.99-1.04)			
Black		1.01 (0.98-1.05)			
Others		0.99 (0.94-1.06)			
Years of schooling		0.99 (0.98-0.99)[c]	0.99 (0.98-0.99)[c]	0.99 (0.99-0.99)[c]	0.99 (0.99-0.99)[c]
Enabling					
Per capita monthly income			0.99 (0.99-0.99)[c]	0.99 (0.99-1.00)	
Type of service					
Private			1.00		
Public			1.01 (0.99-1.03)		
Need					
OIDP				1.01 (1.01-1.01)[b]	1.01 (1.01-1.01)[b]
Treatment needs					
no				1.00	1.00
yes				1.09 (1.06-1.11)[c]	1.08 (1.06-1.11)[c]
Behaviours					
Last dental visit					
< 1 year					1.00
1 to 2 years					1.01 (0.98-1.03)
> 2 years					1.01 (0.98-1.02)
Reason to dental visit					
maintenance					1.00
treatment					1.01 (0.99-1.04)
pain					1.02 (0.99-1.05)
extraction					0.99 (0.96-1.02)
Variance at the city level	0.101 (0.015)[c]	0.102 (0.015)[c]	0.101 (0.015)[c]	0.100 (0.015)[c]	0.100 (0.015)[c]
[Ωμ (se)][d]					

Model 1: mutually adjusted for contextual variables.
Model 2: mutually adjusted for contextual variables and individual predisposing variables.
Model 3: mutually adjusted for contextual variables, individual predisposing and enabling variables.
Model 4: mutually adjusted for contextual variables, individual predisposing, enabling and need variables.
Model 5: mutually adjusted for contextual variables, individual predisposing, enabling, need and behaviours variables.

[a]RR rate ratio.
[b]$P \leq 0.05$; [c]$P \leq 0.01$.
[d]Variance at the city level (standard error) was obtained through random effects.

Table 4. Adjusted association between contextual and individual variables and accumulated attachment loss in elderly people, determined using multilevel Poisson regression.

Variables	Model 1 RR[a] (95% CI)	Model 2 RR[a] (95% CI)	Model 3 RR[a] (95% CI)	Model 4 RR[a] (95% CI)	Model 5 RR[a] (95% CI)
Contextual Variables					
Predisposing	0.85 (0.76-0.95)[b]	0.83 (0.74-0.93)[c]	0.83 (0.74-0.93)[b]	0.83 (0.74-0.92)[b]	0.82 (0.73-0.92)[b]
Individual Variables					
Predisposing					
Age		0.99 (0.98-0.99)[c]	0.99 (0.98-0.99)[c]	0.99 (0.98-0.99)[c]	0.99 (0.98-0.99)[c]
Sex					
Male		1.00	1.00	1.00	1.00
Female		0.76 (0.73-0.78)[c]	0.76 (0.7-0.78)[c]	0.76 (0.73-0.78)[c]	0.77 (0.74-0.78)[c]
Skin colour					
White		1.00			
Brown		1.05 (1.01-1.09)[b]	1.04 (1.01-1.08)[b]	1.04 (1.01-1.08)[b]	1.04 (1.01-1.08)[b]
Black		1.12 (1.06-1.18)[c]	1.12 (1.06-1.17)[c]	1.12 (1.06-1.17)[c]	1.12 (1.06-1.17)[c]
Others		1.04 (0.95-1.16)	1.04 (0.94-1.16)	1.04 (0.94-1.16)	1.04 (0.93-1.15)
Years of schooling		1.01 (1.01-1.01)[c]	1.01 (1.01-1.01)[b]	1.01 (1.01-1.01)[b]	1.01 (1.01-1.01)[c]
Enabling					
Per capita monthly income			1.00 (1.01-1.01)[c]	1.00 (1.01-1.01)[c]	1.00 (1.01-1.01)[c]
Type of service					
Private			1.00		
Public			1.03 (0.99-1.06)		
Need					
OIDP				1.00 (0.99-1.01)	
Treatment needs					
no				1.00	1.00
yes				1.12 (1.08-1.15)[c]	1.12 (1.08-1.15)[c]
Behaviours					
Last dental visit					
< 1 year					1.00
1 to 2 years					1.01 (0.97-1.05)
> 2 years					1.05 (1.01-1.09)[b]
Reason to dental visit					
maintenance					1.00
treatment					0.96 (0.92-1.00)
pain					1.07 (1.01-1.14)[b]
extraction					1.03 (0.98-1.08)
Variance at the city level [Ωμ (se)][d]	0.169 (0.024)[c]	0.172 (0.025)[c]	0.170 (0.024)[c]	0.170 (0.025)[c]	0.174 (0.025)[c]

Model 1: contextual predisposing variable.
Model 2: mutually adjusted for contextual predisposing variable and individual predisposing variables.
Model 3: mutually adjusted for contextual predisposing variable, individual predisposing and enabling variables.
Model 4: mutually adjusted for contextual predisposing variable, individual predisposing, enabling and need variables.
Model 5: mutually adjusted for contextual predisposing variable, individual predisposing, enabling, need and behaviours variables.

[a]RR rate ratio.
[b]P≤0.05; [c]P≤0.01.
[d]Variance at the city level (standard error) was obtained through random effects.

Appendix 1. Accumulated Attachment Loss score

The criteria adopted to define periodontitis in epidemiologic studies have not been consistent.[37] There is a consensus that attachment loss (AL) should be the diagnostic standard for measuring periodontitis and the primary outcome variable used in studies of risk factors for periodontitis as it indicates the extent and severity of past disease activity.[16,38] Most definitions of periodontitis use distinct thresholds of pocket depth and/or AL (ie. ≥ one site with AL ≥ 2mm). However, they do not take into account the number of affected sites while continuous definitions are attractive options for reporting periodontitis in epidemiologic studies.[37]

The Accumulated Attachment Loss (AAL) was estimated using Attachment Loss (AL) measures for each sextant using a ball end CPI probe, according to the following categories: 0-3 mm, 4-5 mm, 6-8 mm, 9-11 mm and ≥12 mm and excluded sextant.[15] The original categories of AL were coded and summed to obtain the final AAL score. Excluded sextant = 0, 0-3 mm = 1.5mm, 4-5mm = 4.5mm, 6-8mm = 7mm, 9-11mm = 10mm and ≥12 mm = 12mm.

The AAL measure used in the present study was developed according to the following reasons: (i) AL measurements indicate the extent and severity of past disease activity, (ii) AL remains a diagnostic standard for measuring periodontitis and (iii) AL is considered as the primary outcome variable used in studies of risk factors for periodontitis.[16,38] The use of AAL as a continuous outcome measure instead of a definition of periodontitis using an arbitrary threshold of AL results in a greater capacity to discriminate groups with different levels of periodontitis.[37]

In this study, the validity of the AAL final score was assessed through comparing the score against previous definitions of periodontal disease as follows: “Moderate to severe” periodontal disease -presence of at least one sextant with pocket depth ≥ 4 mm (CPI > 2) and at least one sextant with CAL ≥ 4 mm (CAL > 0); and “Severe” periodontal disease - presence of at least one sextant with pocket depth ≥ 4 mm (CPI > 2) and at least one sextant with CAL ≥ 6 mm (CAL > 1).[8] The mean and median of AAL were statistically different between groups with and without periodontal disease (both definitions), using t-test and Kruskal-Wallis test, respectively, $P < 0.001$.

In addition, AAL score was statistically correlated with AL original scores and CPI scores in adults (AL scores, rho = 0.742, $P < 0.001$; CPI scores, rho = 0.303, $P < 0.001$) and elderly people (AL scores, rho = 0.727, $P < 0.001$; CPI scores, rho = 0.341, $P < 0.001$).

References

37. Savage A, Eaton KA, Moles DR. Needleman I. A systematic review of definitions of periodontitis and methods that have been used to identify this disease. J Clin Periodontol. 2009;36:458-467.

38. Goodson JM. Diagnosis of periodontitis by physical measurement: interpretation from episodic disease hypothesis. J Periodontol. 1992;63:373-382.

Table Appendix 1. Accumulated Attachment Loss measures of adults and elderly people distributed within the two groups of periodontal disease.

	Moderate to severe periodontal disease[a]		Severe periodontal disease[b]	
	Yes	No	Yes	No
Adults	N = 903	N = 5108	N = 146	N = 5865
AAL Median	13.5	7.5	13.0	7.5
AAL Mean,SE	15.0 (0.4)	7.6 (0.9)	15.6 (1.1)	8.6 (0.2)
Elderly people	N = 522	N = 1874	N = 110	N = 2286
AAL Median	11.5	4.5	11.7	6.0
AAL Mean, SE	12.0 (0.6)	6.0 (0.3)	14.0 (1.2)	6.6 (0.3)

AAL: Accumulated Attachment Loss

[a] Presence of at least one sextant with pocket depth ≥ 4 mm (CPI > 2) and at least one sextant with CAL ≥ 4 mm (CAL > 0)

[b] Presence of at least one sextant with pocket depth ≥ 4 mm (CPI > 2) and at least one sextant with CAL ≥ 6 mm (CAL > 1)

Appendix 2

Andersen's behavioural model

The present research used the Andersen's behavioural model to assess the influence of contextual and individual determinants on periodontal disease as proposed by Thomson and coworkers.[11] The multilevel explanatory framework involves contextual and individual predisposing, enabling and need factors as determinants of health services use. In addition, according to the most recent version of Andersen's behavioural model health care process should be considered, including use of health services and personal health practices.[12]

Predisposing characteristics

Refer to demographic and social composition of communities that influence knowledge and demand for health care services. Organizational values, beliefs and political perspectives are also predisposing factors.[39] Thus, predisposing contextual characteristics included income inequality (Gini index), Human Development Index (HDI) and life expectancy index. Gini index is a "measure of the deviation of the distribution of income among individuals or households within a country of a perfectly equal distribution".[40] The HDI is a composite measure encompassing information on income, education and longevity, revealing social characteristics of communities. Life expectancy is a demographic measure indicating the number of years that a person at a given age can expect to live taking into account age-specific mortality.[41] Individual predisposing factors included demographic characteristics (age and sex) and social factors such as years of schooling and skin colour.

Enabling characteristics

Healthy Policy, financing and organizational factors are considered enabling characteristics that favour services utilization. Organization at contextual level refers to health care coverage, including structures and distribution of health services.[39] Therefore, this research included populational coverage by primary health care (PHC coverage), integration of oral health care teams into primary care (OHT/PHC) and dentists/population ratio (D/P Ratio). Individual financing and organizational factors refer to individual's capacity to access health services from economic perspective, considering whether an individual has a regular source of care. Monthly family income, type of dental services used (public or private) and the number of durable goods in the household were conisderd as enabling individual factors.

Need characteristics

At contextual level, need characteristics include environmental factors and population health indices, including epidemiological indicators of mortality, morbidity and disability. In this study, contextual need characteristics were assessed according to the proportion of adults with diabetes and proportion of adult smokers. At individual level, there are two different approaches. The first is defined by the individual's perception of the treatment needs and the second refers to evaluated need by a health professional or health service.[39] Since disease experiences lead to demand for health services, perceived dental treatment needs and Oral Impacts on Daily Performance (OIDP) were employed to assess individual needs.[18]

Health behaviours

Health behaviour refers to individual attributes that influence personal health practices as well as personal use of health services, partially explaining individual variation in quality of health. Here on, the frequency and pattern of dental services use, including time since the last dental visit (< 1 year; 1 to 2 years; > 2 years) and reason for last dental attendance (check-up, dental treatment, pain, dental extraction) were assessed as health behaviours.

References

39. Babitsch B, Gohl D, von Lengerke T. Re-revisiting Andersen's Behavioral Model of Health Services Use: a systematic review of studies from 1998–2011. GMS Psycho-Social-Medicine. 2012;9: Doc11.

40. World Bank. World Development Indicators 2013. Washington, D.C.: World Bank; 2013. http://data.worldbank.org. Accessed 10 April 2017.

41. WHO 2015. Life expectancy at birth. Indicator. http://www.who.int/healthinfo/indicators/2015/chi_2015_24_life_expectancy.pdf?ua=1. Accessed 12 April 2017.

Appendix 3

Detailed explanation concerning the use of multilevel analysis

The normal distribution of the outcome variable (AAL) was tested through Shapiro-Wilk test and Normal Q-Q plots. P-values of the Shapiro-Wilk Test for adults and elderly people were 0.014 and <0.001, respectively, suggesting non-normal distribution. Normal Q-Q plots confirmed the data was not normally distributed. The overdispersion of the data was handled through using a two-level random intercept model[42].

The association of contextual characteristics (2nd level), individual variables (1st level) with periodontal disease adjusted for confounders was tested using multilevel multivariable Poisson analysis. This statistical technique considers the hierarchy of the observations. Studies that ignore the correlation of observations in a cluster when it exists are substantially more prone to obtain underestimated standard errors resulting in narrow confidence intervals and, therefore, higher Type 1 error.[43]

The two-level data structure used in this study considered the individuals as the first level and the cities as the second level assuming the participants in the same city are not independent of each other and are clustered within cities. This assumption was assessed through the likelihood ratio test according to the following steps. First, the -2log likelihood of the null model was obtained from the maximum likelihood estimation procedure of the standard Poisson regression analysis (STATA Command: xi: poisson). Second, the null model including a random intercept which reflects the variance in the intercepts of the different cities was estimated (STATA Command: xtmepoisson) to obtain the -2log likelihood of the model.[42] The likelihood ratio test was used to compare the -2log likelihood of the model with a random intercept and the -2log likelihood of the model without the random intercept. The difference between the -2log likelihood of the model follows a Chi-square distribution with one degree of freedom.[42] In adults, the difference between the two -2log likelihood was 34363.718-34959.676 = 595.958 ($P < 0.001$) while in elderly people the difference between the two -2log likelihood was 18422.5206-17753.8556 = 668.665 ($P < 0.001$) which suggests the need to correct the analysis for city-level data. A two-level random intercepts and fixed-slopes model structure with individuals nested within cities was fitted.

The association between independent variables and AAL was initially assessed through unadjusted multilevel Poisson regression. Independent variables with a P value <0.05 were considered in the multivariable analysis.

The multivariable analysis was carried out according to the proposed theoretical framework presented in Fig. 1. Contextual predisposing characteristics composed the first model.

Contextual enabling and need characteristics were inserted in the second and third models, respectively. Individual predisposing and enabling variables composed the subsequent models. Independent variables of each model were adjusted for each other. Variables that presented P value < 0.05 were retained in the statistical modeling analysis for adjustment. Rate ratios (RR) estimated in these models indicated the likelihood of having a higher mean of AAL.

The variation of AAL at city-level in the unadjusted and multivariable analyses was assessed using the variance and standard error for AAL at city-level (random effects). The ratio of the variance and the standard error was used to evaluate the statistical significance of the variance at city-level in each model. The significance of the variance at city-level was obtained from Wald statistic, i.e. the variance divided by its standard error squared.[43] Although ICC/VPC provides a more straightforward interpretation of the correlatedness in a hierarchical data set, ICC following a Poisson multilevel model cannot be estimated from the variance of the residuals at individual level.

References

42. StataCorp. Stata: Release 13. Statistical Software. College Station, TX: StataCorp LP, 2013.

43. Twisk JWR. Applied Multilevel Analysis: A Practical Guide to Biostatistics and Epidemiology. Cambridge University Press: New York, 2009.

Appendix 4. Demographic characteristics, periodontal measures and number of teeth between all participants and those with full data according to age groups.

Variable	Adults			Elderly people		
	Full sample N = 7173	Study sample N = 6011	P	Full sample N = 5915	Study sample N = 2369	P
	Mean/% (95% CI)	Mean/% (95% CI)		Mean/% (95% CI)	Mean/% (95% CI)	
Demographic characteristics						
Age, mean	39.3 (39.2-39.4)	39.3 (39.2-39.4)	1.000[a]	69.1 (68.9-69.4)	68.7 (68.4-68.8)	<0.001[a]
Sex, %						
Female	69.9 (67.5-72.2)	71.4 (67.9-74.6)	0.060[b]	63.9 (62.1-65.7)	62.8 (59.6-65.8)	0.350[b]
Male	30.1 (27.8-32.5)	28.6 (25.4-32.1)		36.1 (34.3-37.9)	37.2 (34.2-40.4)	
Skin colour, %			0.311[b]			0.226[b]
White	46.1 (42.7-49.6)	47.2 (43.6-50.8)		53.4 (49.7-56.9)	53.4 (48.8-58.0)	
Brown	39.7 (36.3-43.3)	39.6 (35.7-43.6)		30.0 (25.9-34.5)	28.5 (23.1-34.4)	
Black	12.4 (10.5-14.6)	11.4 (9.7-13.4)		14.8 (10.9-19.8)	16.4 (10.5-24.8)	
Others	1.8 (1.2-2.9)	1.8 (1.1-2.9)		1.8 (1.2-2.9)	1.7 (0.9-3.0)	
Periodontal measures						
Accumulated attachment loss, mean	6.9 (6.6-7.3)	8.7 (8.4-9.1)	<0.001[a]	6.3 (5.5-7.0)	6.9 (5.8-8.0)	<0.001[a]
CAL number of sextants, %			<0.001[b]			0.210[b]
0-3mm	76.5 (73.0-79.6)	76.0 (72.4-79.3)		55.5 (45.9-64.6)	51.9 (42.2-61.5)	
4-5mm	17.1 (14.6-19.9)	17.4 (15.0-20.0)		31.1 (23.6-39.9)	34.1 (25.3-44.2)	
6-8mm	4.8 (3.6-6.3)	4.8 (3.4-6.6)		11.1 (7.6-15.8)	11.3 (7.8-16.1)	
9-11mm	0.9 (0.4-1.7)	1.2 (0.7-2.2)		0.9 (0.4-1.7)	1.1 (0.5-2.2)	
>12	1.4 (0.5-4.0)	0.6 (0.3-1.3)		1.4 (0.5-4.0)	1.6 (0.5-5.0)	
Number of teeth, mean	23.3 (22.9-23.6)	24.0 (23.6-24.2)	<0.001[a]	6.8 (5.9-7.6)	13.2 (12.3-14.1)	<0.001[a]

[a]P-values refer to t-test
[b]P-values refer to Chi-square test

Appendix 5. Mean Accumulated Attachment Loss (in millimeters) according to low, moderate and high levels of the contextual variables

Contextual variables	Adults	Older people
Predisposing characteristics		
Gini Index		
Low	5.2	6.3
Moderate	10.2	8.4
High	8.0	8.0
HDI		
Low	7.2	7.0
Moderate	6.0	6.9
High	5.7	6.3
Life expectancy index		
Low	7.2	7.1
Moderate	5.9	6.3
High	5.9	6.3
Enabling characteristics		
D/P Ratio		
Low	11.8	8.1
Moderate	6.5	7.9
High	3.8	5.0
PHC coverage		
Low	8.2	8.0
Moderate	10.5	8.4
High	5.4	5.3
OHT/PHC		
Low	14.0	7.6
Moderate	7.8	7.7
High	2.8	6.7
Need characteristics		
% of adults with diabetes		
Low	5.0	6.3
Moderate	11.3	8.9
High	6.5	6.9
% of adults smokers		
Low	4.4	6.4
Moderate	5.1	5.2
High	8.7	8.6

HDI: Human Development Index
D/P Ratio: dentists/population ratio
PHC coverage: population coverage by primary health care
OHT/PHC: integration of oral health care teams into primary care