Journal of Dentistry 44 (2016) 50–56

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.intl.elsevierhealth.com/journals/jden

Social position, social ties and adult's oral health: 13 year cohort study

Mario Vianna Vettore[a,*], Eduardo Faerstein[b], Sarah Ruth Baker[a]

[a] Unit of Dental Public Health, School of Clinical Dentistry, University of Sheffield, 19 Claremont Crescent, Sheffield S10 2TA, United Kingdom
[b] Department of Epidemiology, Institute of Social Medicine, State University of Rio de Janeiro, Pavilhão João Lyra Filho, 7° andar blocos D e E, e 6° andar bloco E., Rua São Francisco Xavier, 524—Maracanã, Rio de Janeiro CEP 20550-013, Brazil

ARTICLE INFO

Article history:
Received 10 July 2015
Received in revised form 1 November 2015
Accepted 3 December 2015

Keywords:
Social determinants of health
Social support
Social networks
Longitudinal studies
Tooth loss
Structural equation modelling

ABSTRACT

Objectives: This study explored different pathways by which social position and social ties influence adult's oral health over a 13-year period.
Methods: A cohort investigation (Pro-Saúde Study) was conducted of non-faculty civil servants at a university in Rio de Janeiro, Brazil ($N = 1613$). Baseline data collected in 1999 included age, social position, social ties, and access to dental care. Psychological factors and smoking were assessed in 2001, whereas tooth loss and self-rated oral health (SROH) were collected in 2012. A hypothesised model exploring different direct and indirect pathways was developed and tested using structural equation modelling.
Results: The model was a good fit to the data and accounted for 40% and 27% of the variance in tooth loss and SROH, respectively. A greater social position was linked to more social ties ($\beta = 0.31$), health insurance ($\beta = 0.48$), low psychological distress ($\beta = 0.07$), less smoking ($\beta = -0.21$), more regular dental visiting ($\beta = 0.30$), less tooth loss ($\beta = -0.44$) and better SROH ($\beta = -0.25$) over time. Social position ($\beta = 0.0005$) and social ties ($\beta = -0.0015$) were linked indirectly with psychological distress, smoking and tooth loss. Social position was linked indirectly with social ties, psychological distress and SROH ($\beta = -0.0071$).
Conclusions: Poor social position and weak social ties were important predictors for tooth loss and poor SROH in adults over the 13-year period. Direct and indirect pathways via psychological factors and smoking on the aforementioned relationships were identified, suggesting different areas of intervention to promote adults' oral health.
Clinical significance: Adult's oral health is influenced by social conditions through direct and indirect pathways, including via psychological factors and smoking.

1. Introduction

A large body of evidence suggests the role of unfavourable socio-economic conditions and weak social ties on a range of oral health outcomes. However, previous research on social predictors of oral health has largely been supported by cross-sectional studies and few studies have examined potential pathways by which these relationships may occur [1–3].

Robust findings from epidemiologic research on social determinants of oral health are underpinned by the so-called "risk factor approach" through different statistical modelling techniques [3]. Although such approach has been useful in identifying independent risk factors for oral conditions, empirical studies on the explanatory theories of social determinants of oral health remain scarce [1].

The life-course perspective is considered the most comprehensive explanation to understand the influence of social conditions on health across the lifespan [4]. Life-course epidemiology acknowledges that health inequalities result from the interconnection of material, behavioural and psychosocial factors over time [1]. However, life-course studies applied to oral health predominantly examined children's and young adult's oral health across socioeconomic trajectory groups using statistical modelling [5–7]. Thus, the resulting potential of the life-course approach in clarifying the mediating factors and mechanisms between social factors and oral health through behavioural and psychological pathways remains untapped.

Different forms of individual social relationships such as friendship and family social ties have been suggested to play a critical role in shaping people's oral health over time [8–10]. Individual social ties refer to the extent and quality of social interactions represented by one's social network and social support [11]. Social network and social support are interconnected terms since different types of social support are embedded within an individual's social networks, which are sources of mutual social

* Corresponding author.
E-mail addresses: m.vettore@sheffield.ac.uk (M.V. Vettore), efaerstein@gmail.com (E. Faerstein), s.r.baker@sheffield.ac.uk (S.R. Baker).

http://dx.doi.org/10.1016/j.jdent.2015.12.004
0300-5712/

support [12]. Weak social ties have been associated with poor health-related behaviours and psychological distress, which are considered the potential mechanisms whereby health problems can accrue from poor social relationships [13,14].

The understanding of the underlying mechanisms on the relationship between social characteristics and oral health throughout adult life is unclear and requires further investigation. The objective of this study was to develop and test a theoretical model investigating the direct and indirect (mediated) pathways between behavioural, psychological and access to dental care by which social position and social ties influence adult's oral health over a 13-year period.

2. Methods

2.1. Cohort design and participants

The Pro-Saúde Study was a prospective cohort study involving non-faculty civil servants from university campuses in the state of Rio de Janeiro, Brazil. Baseline collection was carried out in 1999 involving 4030 adults (53.6% females) aged 22–67 years (response rate = 90.4%). The cohort was followed and 3574 (response rate = 80.2%) and 3058 (response rate = 68.6%) participants were re-assessed in 2001 and 2012, respectively. All technical and administrative permanent staffs were included. Workers on leave of absence for non-medical reasons, those transferred to other institutions and participants with missing values for variables were excluded. This resulted in a final sample of 1613 participants (see online Supplementary Appendix 1).

2.2. Ethics

The project was approved by the Research Ethics Committee of the Pedro Ernesto Teaching Hospital (Hospital Universit ário Pedro Ernesto), Rio de Janeiro, Brazil.

2.3. Development of a theoretical model

A hypothesised model incorporating possible pathways on the relationship between socio-economic position, social ties and oral health in adults has been conceptualized, developed and tested considering three dimensions: psychological (stress), behavioural (smoking) and access to dental care (health insurance and frequency of dentist visits) [1,11,15] (Fig. 1). The mechanisms are suggested to operate through adjacent levels. For example, higher social position and more social ties would directly predict access to dental care (having health insurance, more frequent dental visiting) and behaviour (no smoking), lower stress (psychological distress and work stress), and better oral health (less tooth loss and better self-rated oral health). In addition, social position and social ties would predict oral health with complex, direct and indirect relationships between non-adjacent dimensions.

2.4. Measures

Self-administered questionnaires filled out in the workplace were used to collect data. For testing the hypothesised model, social position, social ties, were latent variables and the remainder observed variables.

2.5. Social position

Social position was a latent variable measured by three indicators in 1999: property status (1 = rented/loaned/borrowed or 2 = owner (fully paid/mortgage), education (1 = ≤10 years, 2 = 11–15 years, 3 = ≥16 years) as number of concluded years at school, and per capita monthly income (1 = <3 Brazilian minimal wages, 2 = 3–6 BM Wages, 3 = >6 BMW) considering 1 BMW = US $57.17 in 1999. A higher score for this latent variable indicated better social position.

2.6. Social ties

Social ties was a latent variable measured by three indicators in 1999: the 19-item perceived social support questionnaire comprises five dimensions of functional social support: material, affective, emotional, positive social interaction and information [16]. A higher score indicates greater perceived social support [17,18]. Social network was collected by means of the Medical Outcomes Study (MOS) questionnaire [19].

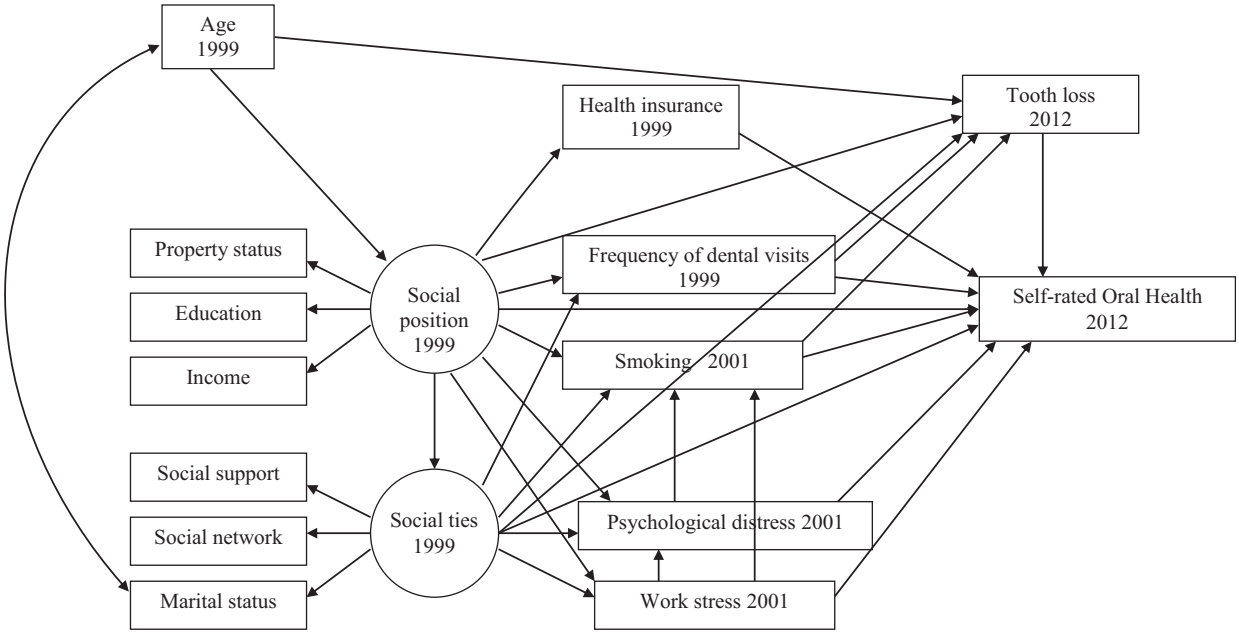

Fig. 1. Full hypothesised model. Arrows indicate hypothesised direct pathways between variables. Latent variables are in ellipses, measured variables in rectangles, and error terms in circles.

Participants informed the number of relatives and friends they feel comfortable with and who he/she can talk to about almost everything [18]. The tertiles of the sample was used to compose three groups; 1 = 0–3 friends and/or relatives, 2 = 4–6, and 3 = ≥7 friends and/or relatives [18]. A higher number of relatives and friends indicates greater social network. Psychometric properties of the perceived social support and social network scales revealed that they were adequate for the studied population [17,18]. Internal consistency and reliability of the social support scale in the studied population were evaluated through Cronbach coefficient and intraclass correlation coefficient using two-way mixed effects in a test–retest reliability study. The Cronbach coefficient was 0.95 at test and 0.97 at retest, and intraclass correlation coefficient was 0.88 (95% CI = 0.85–0.91) [17].

Table 1
Descriptive characteristics of the sample.

		All participants (*N* = 4030)	Final analytic sample (*N* = 1613)	*P*-value
Demographic characteristics 1999	Age (years), Mean (SD)	40.2 (8.8)	38.5 (7.5)	<0.001
	Sex, *N* (%)			0.598
	Male	1792 (44.5)	699 (43.3)	
	Female	2238 (55.5)	914 (56.7)	
	Ethnicity, *N* (%)			<0.001
	White	2014 (52.5)	900 (55.8)	
	Brown/Pardo	998 (26.0)	474 (29.4)	
	Black	824 (21.5)	239 (14.8)	
Social position 1999	Property Status, *N* (%)			0.208
	Owner	2611 (67.5)	1118 (69.3)	
	Rented/Loaned/Borrowed	1253 (32.5)	495 (30.7)	
	Education (school years), *N* (%)			<0.001
	≤10	946 (23.8)	263 (16.3)	
	11–15	1430 (35.9)	606 (37.6)	
	≥16	1607 (40.3)	744 (46.1)	
	Income[a],*N* (%)			0.033
	<3 BMW[b]	1038 (27.4)	387 (24.0)	
	3–6 BMW	1391 (36.7)	618 (38.3)	
	>6 BMW	1357 (35.8)	608 (37.7)	
Social ties 1999	Social support, Mean (SD)	81.2 (17.8)	82.6 (16.7)	0.005
	Social network[c], *N* (%)			<0.001
	0–3	1579 (39.2)	538 (33.4)	
	4–6	1200 (29.8)	536 (33.2)	
	≥7	1251 (31.0)	539 (33.4)	
	Marital status, *N* (%)			0.065
	Divorced/Widowed	727 (18.5)	257 (15.9)	
	Single	805 (20.5)	351 (21.8)	
	Married	2397 (61.0)	1005 (62.3)	
Access 1999	Health insurance, *N* (%)			<0.001
	No	1739 (43.4)	621 (38.5)	
	Yes	2266 (56.6)	992 (61.5)	
	Frequency of dentist visits, *N* (%)			0.927
	As needed	1345 (33.7)	542 (33.6)	
	Less than once a year	925 (23.2)	368 (22.8)	
	Every year	1717 (43.1)	703 (43.6)	
Behavioural 2001	Smoking, *N* (%)			<0.001
	Yes	1077 (42.5)	331 (20.5)	
	No	1460 (57.5)	1282 (79.4)	
Psychological variables 2001	Psychological distress, Mean (SD)	22.8 (5.8)	23.1 (5.8)	<0.001
	Work stress, *N* (%)			0.723
	High strain	584 (19.8)	324 (20.1)	
	Active job	565 (19.2)	315 (19.5)	
	Passive job	1023 (34.8)	534 (33.1)	
	Low strain	773 (26.2)	440 (27.3)	
Oral health measures 2012	Tooth loss, *N* (%)			<0.001
	None	353 (16.8)	324 (20.1)	
	One or few	1034 (49.4)	832 (51.6)	
	Several	450 (21.5)	326 (20.2)	
	Almost all/all	258 (12.3)	131 (8.1)	
	Self-rated oral, *N* (%)			0.811
	Very good health	340 (16.2)	267 (16.6)	
	Good	937 (44.5)	743 (46.1)	
	Regular	621 (29.5)	448 (27.8)	
	Poor/bad	180 (8.6)	134 (8.3)	
	Very poor/very bad	27 (1.3)	21 (1.3)	

P-values refer to Pearson Chi-square test, except for age, social support and psychological distress (*t*-test).
[a] Per capita monthly income.
[b] BMW = Brazilian Minimal Wage. 1 BMW = US $57.17 in 1999.
[c] Number of friends and/or relatives.

Unweighted Kappa coefficients for social network scale were 0.70 (95% CI 0.62–0.77) and 0.77 (95% CI 0.70–0.82) for number of relatives and number of friends, respectively [20]. The third indicator, marital status was categorised as: (1) = divorced and widowed, (2) = single, (3) = married. Divorced and widowed people are more predisposed to social isolation, whereas married people tend to have higher levels of social connectedness compared to other marital status groups [21].

2.7. Age, access, oral health behaviour and psychological variables

The variables measured in 1999 and 2001 included: Age in 1999; Access in 1999 (health insurance: 1 = no, 2 = yes; and frequency of dentist visits: 1 = as needed, 2 = less than once a year, 3 = every year); Behavioural in 2001 (current smoker: 1 = yes, 2 = no). Psychological variables assessed in 2001 were psychological distress and work stress. Psychological distress was measured by the Brazilian version of the General Health Questionnaire-12 items (GHQ-12) [22,23].

The presence of common mental disorders during the previous two weeks are scored '1' and summed over the items. A higher score indicated greater psychological distress. Karasek demand-control questionnaire assess perceptions of demand and control dimensions of work stress [24,25]. Participants were classified as 1 = high strain (high job demands and low control), 2 = active job (high job demands and high control), 3 = passive job (low job demands and low control), 4 = low strain (low job demands and high control). Higher scores indicated lower work stress.

2.8. Oral health outcomes

Oral health outcomes registered in 2012 were tooth loss and self-rated oral health. Tooth loss was a self-reported measure assessed by the question: 'What option better corresponds to the number of teeth you have lost?' (1 = none, 2 = one or few, 3 = several, 4 = almost all/all). Previous studies concluded that there is good agreement between subjective self-reported tooth loss and number of natural teeth. Therefore, self-reported tooth loss can be considered a valid measure with appropriate discriminatory capacity of clinical tooth loss [26–28]. In this study, the reliability of self-reported tooth loss as ordinal rating scale was good (Kappa = 0.75; 95% CI = 0.64–0.87) [29]. Self-rated oral health (SROH) was measured in response to the question 'In general, how would you rate your oral health status?' (1 = very good, 2 = good, 3 = fair, 4 = poor/bad, 5 = very poor/very bad) [30]. This item was previously tested showing very good test-retest reliability (Kappa = 0.80; 95% CI = 0.69–0.89) [31].

2.9. Statistical analysis

Descriptive and bivariate statistics were used to describe the sample and to compare the demographic and social position characteristics between all participants and those with complete data. Comparisons between groups for categorical variables were tested by Pearson Chi-square test and *t*-test for age, social support and psychological distress.

Structural equation modelling (SEM) was used to test the interrelationships between variables according to the hypothesised model [32]. AMOS 22.0 was used to exam the hypothesised model and to create a statistically parsimonious model. Estimates the total effects, which are made up of both the direct effects (a path direct from one variable to another e.g. health insurance to self-rated oral health; see Fig. 1) and indirect effects (a path mediated through other variables e.g. social position to self-rated oral health mediated via health insurance; see Fig. 1). Total indirect effects represent the sum of one or more specific paths. We assessed whether mediation was present by testing the significance of the indirect effect using the bias-corrected bootstrap confidence intervals [33]. Bootstrapping is where multiple samples ($n = 900$) are randomly drawn from the original sample; the structural model is then estimated in each dataset, and the results averaged. This technique has been shown to result in less biased estimates under conditions of nonnormality and for sample sizes ≥ 200. The bootstrap estimates and standard errors (together with bias-corrected 95% confidence intervals (CIs)) are then compared to the results from the original sample to examine stability of parameters and test statistics. As recommended, model fit was evaluated using a range of indices from the three fit classes;

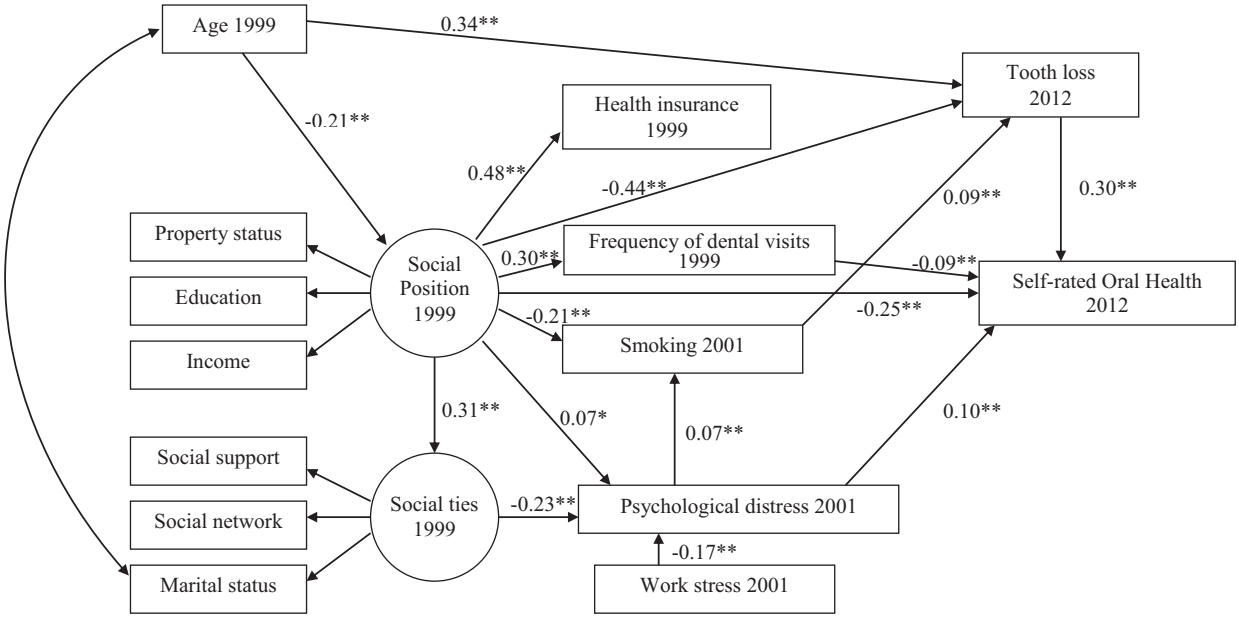

Fig. 2. Direct effects (bootstrapped standardized estimates) for the final statistically parsimonious model represented through solid lines.
For Bootstrapped Se/BC 95% CI, see Appendix 3 (Supplementary information). Error terms and covariances omitted for ease of interpretation. $^{**}P < 0.01$, $^{*}P < 0.05$.

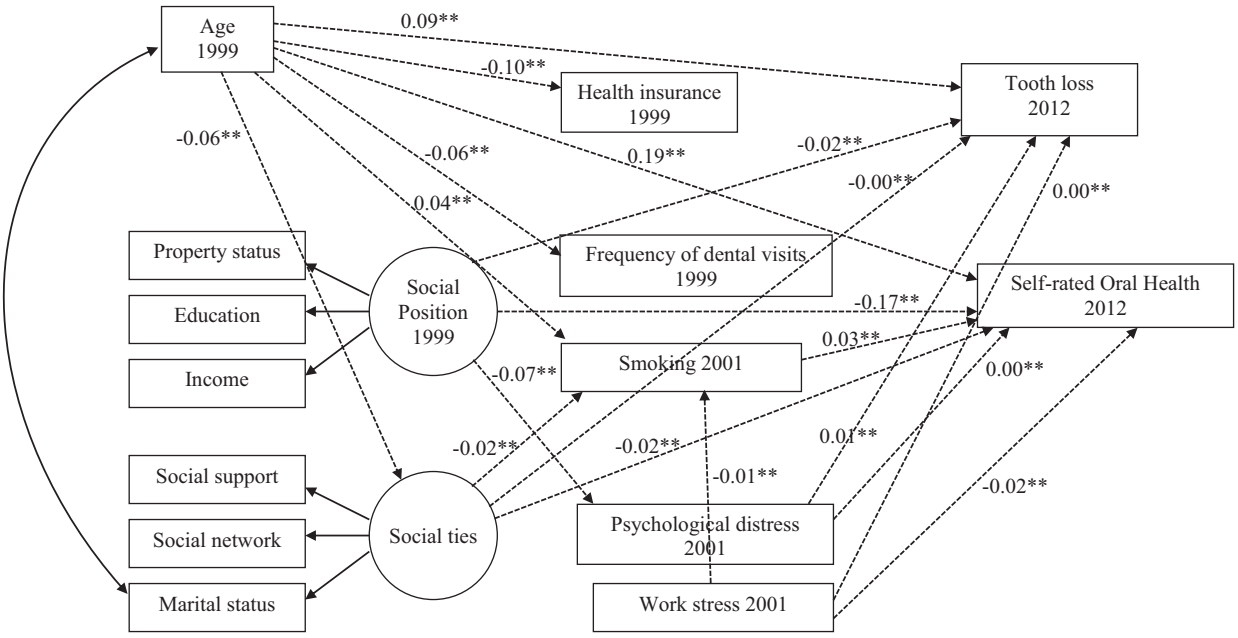

Fig. 3. Significant indirect effects (bootstrapped standardized estimates) for the final statistically parsimonious model represented through dashed lines. For Bootstrapped Se/BC 95% CI, see Appendix 4 (Supplementary information). For calculation of specific indirect paths, see Appendix 5. Error terms and covariances omitted for ease of interpretation. $^{**}P < 0.01$, $^{*}P < 0.05$.

absolute, parsimony adjusted and comparative. A χ^2/df ratio < 3.0, RMSEA values <0.06, CFI and GFI of 0.90 or above and an SRMR <0.08 were taken to indicate an acceptable model fit [34].

3. Results

3.1. Descriptive

Descriptive characteristics of all participants ($N = 4030$) and those with complete data ($N = 1613$) are presented in Table 1. Adults with complete data were older, more schooled, with higher income and with stronger social ties ($p \leq 0.05$). Participants with complete data smoked less, have higher scores of psychological distress and experienced more tooth loss ($p \leq 0.05$). Of the 1613 participants, 56.7% were women and 55.8% White ethnicity. Education was predominantly high (46.1%), and 38.3% have per capita family income between 3 and 6 BMW. Most of participants were married (62.3%), have health insurance (61.5%), visit a dentist every year (43.6%) and were non-smokers (79.4%) (Table 1).

3.2. SEM analysis

3.2.1. Testing the theoretical model

The theoretical model (Fig. 1) hypothesised that better social position and more social ties would directly predict having health insurance, more frequent dental visiting, no smoking, lower psychological distress and lower work stress. In addition, worst social position and low social ties were hypothesised to predict both outcomes; less tooth loss and better self-rated oral health. Indirect effects of social position and social on oral health via access to dental care, psychological factors and smoking ties were also hypothesised. The model was an acceptable fit to the data meeting four of the a priori criteria [χ^2/df = 2.665, p-value < 0.001, RMSEA = 0.032 (95% CIs 0.026–0.038), CFI = 0.963, SRMR = 0.027] (Model 1).

3.2.2. Parsimonious model

A number of the direct hypothesised paths were non-significant in the theoretical model. In order to create a statistically parsimonious model, these non-significant direct paths were removed and the model re-estimated [χ^2/df = 2.538, p-value < 0.001, RMSEA = 0.031 (95% CIs 0.025–0.037), CFI = 0.959, SRMR = 0.029] (Model 2). This model was then compared to Model 1 (M2 vs. M1: Δx^2 (11) = 0.127, ns). The non-significance of this difference test indicated that the dropped pathways were not important to the model. In this final model, 27% and 40% of the variance was accounted for in self-rated oral health and tooth loss respectively (Figs. 1 and 2). The total effects that combines the direct and indirect paths are presented as online Supplementary Appendix 2.

3.3. Direct effects

All of the direct paths in the parsimonious model were in the expected direction (Fig. 2, Appendix 3). Being older was linked to poor social position ($\beta = -0.20$) and more tooth loss ($\beta = 0.36$). A greater social position was linked to having more social ties ($\beta = 0.31$), health insurance ($\beta = 0.48$), low psychological distress ($\beta = 0.07$), less smoking ($\beta = -0.18$), more regular dental visiting ($\beta = 0.31$), less tooth loss ($\beta = -0.44$) and better self-rated oral health ($\beta = -0.25$). More social ties was linked to low psychological distress ($\beta = -0.23$). Less work stress was linked to low psychological distress ($\beta = -0.17$). Psychological distress was linked to smoking ($\beta = 0.08$). Smoking was linked to more tooth loss ($\beta = 0.08$). Less frequent dental visiting ($\beta = -0.09$), high psychological distress ($\beta = 0.10$), more tooth loss ($\beta = 0.31$) and lower social position ($\beta = -0.25$) were linked to poor self-rated oral health.

3.4. Indirect effects

There were a number of significant total indirect effects within the model. Age was linked indirectly with social ties, smoking, tooth loss, dental visiting, health insurance and SROH (Fig. 3,

Appendix 4). Social position was linked indirectly with psychological distress, tooth loss and SROH. Work stress and social ties were linked indirectly with smoking, tooth loss, and SROH. Psychological distress was linked indirectly with tooth loss and SROH. Finally, smoking was linked indirectly with SROH. These are the total indirect effects and are made up of a number of specific indirect paths. To determine which mediated path is more important within the model, specific indirect paths between non-adjacent variables were calculated through the multiplication of standardized beta coefficients estimated in the direct paths in the parsimonious model (see online Supplementary Appendix 5). The indirect pathway between social position and tooth loss can be broken down to three paths: (1) Lower social position was linked to tooth loss via smoking ($\beta = -0.0144$), (2) Lower social position was linked to tooth loss via psychological distress and smoking ($\beta = 0.0005$), 3) Lower social position was linked to tooth loss via social ties, psychological distress, smoking ($\beta = -0.0005$). Similarly, social position was related to SROH via a number of pathways: (1) Social position–smoking–tooth loss–SRHO ($\beta = -0.0045$), (2) Social position–dental visiting–SRHO ($\beta = -0.0279$), (3) Social position–psychological distress–SRHO ($\beta = 0.0070$), (4) Social position–social ties–psychological distress-SRHO ($\beta = -0.0071$). In addition, social ties was linked to tooth loss via psychological distress and smoking ($\beta = -0.0015$). As can be seen, in relation the social position and social ties to tooth loss, those paths involving psychological distress and smoking were the strongest pathways.

4. Discussion

In this prospective cohort study involving Brazilian adults, poor social position and weak social ties were strongly associated with tooth loss and poor SROH over a 13-year follow-up period. The relationships were tested using a theoretical model encompassing access to dental care, and behavioural and psychological pathways. In a final robust model with adequate fit to the data, 27% and 40% of the variance in SROH and tooth loss were explained and a number of significant direct and indirect pathways were consistently identified. In addition, specific indirect pathways analysis revealed a variety of mechanisms by which social position and social ties can influence oral health. Therefore, the present findings support the temporal relationship between socioeconomic inequalities, social ties and adult's oral health, suggesting the importance of key structural social determinants and intermediary factors on shaping adult's oral health [35].

Previous longitudinal studies consistently demonstrated that adolescents and adults oral health are predicted by childhood socioeconomic disadvantage offering compelling support for the social-origins hypothesis [5–7]. Psychological factors and health-related behaviours also showed a clear socioeconomic trajectory from childhood to adulthood [6]. Nevertheless, the mechanisms by which these relationships occur over time during adulthood are less well established. There is considerable evidence on the harmful effect of weak social ties on oral heath, including on SROH and tooth loss [9,10,36,37]. Different pathways, such as health behaviours and psychological distress have been suggested to explain this relationship. However, these mechanisms have not been evaluated due to the cross-sectional design of most previous investigations. Therefore, this is the first longitudinal study testing the influence of social position and social ties on adult's oral health using an a priori theoretical model.

In the present study, a lower social position predicted tooth loss and poor SROH through direct and indirect mechanisms whereas low social ties were associated with oral health outcomes via indirect effects. Our findings on the direct effect of socio-economic status on the number of sound teeth in adults and the mediating effect of access to dental attendance on this association has been shown previously [38]. Other studies have also evaluated the pathways between social inequalities and oral health. Behavioural and dental attendance pathways partially explained the socio-economic disparities in children's oral health [39], and early maternal enabling factors, including education, cognitive ability and psychological distress predicted caries in adolescents through psychosocial stress, dental preventive behaviour and access [40]. However, no previous study has attempted to test a complex theoretical model on the direct and indirect links on the influence of social position and social ties on adult's oral health via access to dental care, behavioural and psychological pathways.

The strengths of this study include the temporal order between social position, social ties the potential paths and oral health outcomes, together with the use of structural equation modelling, which is considered the most appropriate statistical approach to identify direct and indirect pathways between predictors and health outcomes in longitudinal studies using complex theoretical frameworks. Nevertheless, some limitations should be considered. The studied sample is a specific occupational cohort of civil servants in Rio de Janeiro and the findings should not be generalised. Future studies examining the longitudinal effects of socioeconomic disadvantage on oral health should consider more representative socio-economic groups. For example, employed, those not working, and home-workers. The reduction in the number of participants during the period of study due to withdrawals and missing data may be a potential source of selection bias. In this study, tooth loss was a self-reported oral health outcome which might have brought inaccuracy into the findings. Nonetheless, previous studies argue that self-reported and clinical tooth loss produces similar figures [26–28]. The fact that statistical associations were found between independent variables and tooth loss, as measured, suggests its adequate validity. However, some of the significant indirect paths were very low as their betas were presented as zero due to numeric approximation of decimal places. SROH have been assessed using different single-item global measures which makes difficult the comparability of studies. However, regardless of the wording, predictors for SROH were similar when two different global oral health questions were compared [41].

Future studies should investigate society-level determinants and the use of stratified models according to other demographic characteristics since these relationships and mechanisms seem to differ, for example, between sex and ethnic groups [42,43].

Although this study was conducted during adulthood, the results of the present work support the 'accumulation risk model' and the 'pathway model' originally described in life course epidemiology [44]. These models were supported in this research since social position, dental visiting, psychological distress and smoking showed independent effects on SROH. In addition, important clusters of risk exposures and sequences of linked predictors were relevant in the specific indirect paths. A robust direct relationship was observed between social position and tooth loss ($\beta = -0.44$) and the strongest pathways linking social position and social ties with tooth loss were observed via psychological distress and smoking ($\beta = -0.44$ and -0.46). On the other hand, the magnitudes of the association between dental visiting and oral health outcomes via direct and indirect paths were modest. This suggests that oral health promotion activities to enhance adult's oral health should focus on social determinants and common risk factors (e.g. smoking) rather than on the health care (e.g. frequency of dental visits). Our findings give strong support for the social epidemiology theory in relation to material, psychosocial and behavioural pathways for understanding oral health inequalities in the adult population.

Competing interests

The authors declare no potential conflicts of interests with respect to the authorship and/or publication of this article.

Funding

This study was supported by Grant E-26/110.119/2014 from FAPERJ (Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jdent.2015.12.004.

References

[1] K.L. Sisson, Theoretical explanations for social inequalities in oral health, Community Dent. Oral Epidemiol. 35 (2007) 81–88.
[2] S.R. Baker, A. Mat, P.G. Robinson, What psychosocial factors influence adolescents' oral health? J. Dent. Res. 89 (2010) 1230–1235.
[3] S.R. Baker, B.G. Gibson, Social oral epidemi(olog)2y where next: one small step or one giant leap? Community Dent. Oral Epidemiol. 42 (2014) 481–494.
[4] N. Krieger, A glossary of social epidemiology, J. Epidemiol. Community Health 55 (2001) 693–700.
[5] W.M. Thomson, R. Poulton, B.J. Milne, A. Caspi, J.R. Broughton, K.M. Ayers, Socioeconomic inequalities in oral health in childhood and adulthood in a birth cohort, Community Dent. Oral Epidemiol. 32 (2004) 345–353.
[6] R. Poulton, A. Caspi, B.J. Milne, W.M. Thomson, A. Taylor, M.R. Sears, et al., Association between children's experience of socioeconomic disadvantage and adult health: a life-course study, Lancet 360 (2002) 1640–1645.
[7] M.A. Peres, K.G. Peres, A.J. de Barros, C.G. Victora, The relation between family socioeconomic trajectories from childhood to adolescence and dental caries and associated oral behaviours, J. Epidemiol. Community Health 61 (2007) 141–145.
[8] G.A. Lamarca, C. Leal Mdo, A.T. Leao, A. Sheiham, M.V. Vettore, Oral health related quality of life in pregnant and post partum women in two social network domains; predominantly home-based and work-based networks, Health Qual. Life Outcomes 10 (2012) 5.
[9] J. Aida, K. Kondo, N. Kondo, R.G. Watt, A. Sheiham, G. Tsakos, Income inequality, social capital and self-rated health and dental status in older Japanese, Soc. Sci. Med. 73 (2011) 1561–1568.
[10] J. Aida, T. Hanibuchi, M. Nakade, H. Hirai, K. Osaka, K. Kondo, The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis, Soc. Sci. Med. 69 (2009) 512–518.
[11] I. Kawachi, L. Berkman, Social cohesion, social capital and health, in: L. Berkman, I. Kawachi (Eds.), Social Epidemiology, Oxford University Press, New York, 2000, pp. 174–190.
[12] T.E. Seeman, Social ties and health: the benefits of social integration, Ann. Epidemiol. 6 (1996) 442–451.
[13] K.E. Burke, R. Schnittger, B. O'Dea, V. Buckley, J.P. Wherton, B.A. Lawlor, Factors associated with perceived health in older adult Irish population, Aging Ment. Health 16 (2012) 288–295.
[14] L.S. Berkman, T. Glass, Social integration, social networks, social support, and health, in: M. Marmot, R.G. Wilkinson (Eds.), Social Determinants Health, Oxford University Press, New York, 2006, pp. 137–173.
[15] M. Rutter, Psychosocial influences: critiques, findings, and research needs, Dev. Psychopathol. 12 (2000) 375–405.
[16] C. Sherbourne, A. Stewart, The MOS social support theory, Soc. Sci. Med. 32 (1991) 705–714.
[17] R.H. Griep, D. Chor, E. Faerstein, C. Lopes, Apoio social: confiabilidade teste–reteste de escala no Estudo Pro-Saude, Cad. Saude Publ. 19 (2003) 625–634.
[18] D. Chor, R.H. Griep, C. Lopes, E. Faerstein, Medidas de rede e apoio social no Estudo Pro-Saude: pretestes e estudo piloto, Cad. Saude Publ. 17 (2001) 887–896.
[19] L.F. Berkman, S.L. Syme, Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents, Am. J. Epidemiol. 109 (1979) 186–204.
[20] R.H. Griep, C. Dóra, E. Faerstein, C. Lopes, Test–retest reliability of measures of social network in the Pró-Saúde Study, Rev. Saude Publ. 37 (2003) 379–385.
[21] L.I. Pearlin, J.S. Johnson, Marital status, life-strains and depression, Am. Sociol. Rev. 42 (1977) 704–715.
[22] D.P. Goldberg, The Detection of Psychiatric Illness by Questionnaire, Oxford University Press, London, 1972.
[23] J.J. Mari, P. Williams, A comparison of the validity of two psychiatric screening questionnaires (GHQ-12 and SRQ-20) in Brazil, using relative operating characteristic (ROC) analysis, Psychol. Med. 15 (1985) 651–659.
[24] T. Theorell, The demand-control-support model for studying health in relation to the work environment: an interactive mode, in: K. Orth-Gómer, N. Schneiderman (Eds.), Behavioral Medicine Approaches to Cardiovascular Disease, Lawrence Erlbaum Associates, Mahwah, US, 1996, pp. 69–85.
[25] R.A. Karasek, M. Theorell, Healthy Work: Stress, Productivity and the Reconstruction of Working Life, Basic Books, New York, 1990.
[26] L. Unell, B. Söderfeldt, A. Halling, J. Paulander, D. Birkhed, Oral disease, impairment, and illness: congruence between clinical and questionnaire findings, Acta Odontol. Scand. 55 (1997) 127–132.
[27] G. Axelsson, S. Helgaddttir, Comparison of oral health data from self-administered questionnaire and clinical examination, Community Dent. Oral Epidemiol. 23 (1995) 365–368.
[28] G.H. Gilbert, L.S. Chavers, B.J. Shelton, Comparison of two methods of estimating 48-month tooth loss incidence, J. Public Health Dent. 62 (2002) 163–169.
[29] J. Cunha-Cruz, P. Nadanovsky, E. Faerstein, C.S. Lopes, Routine dental visits are associated with tooth retention in brazilian adults: The Pro-Saude study, J. Public Health Dent. 64 (2004) 216–222.
[30] D. Locker, E.W. Mscn, A. Jokovic, What do older adults' global self-ratings of oral health measure? J. Public Health Dent. 65 (2005) 146–152.
[31] G. Afonso-Souza, P. Nadanovsky, G.L. Werneck, E. Faerstein, D. Chor, C.S. Lopes, Test–retest reliability of self-perceived oral health in an adult population in Rio de Janeiro, Brazil, Cad. Saude. Publ. 23 (2007) 1483–1488.
[32] R.B. Kline, Principles and Practice of Structural Equation Modeling, The Guildford Press, New York, 2005.
[33] D.P. MacKinnon, C.M. Lockwood, J.M. Hoffman, S.G. West, V. Sheets, A comparison of methods to test mediation and other intervening variable effects, Psychol. Methods 7 (2002) 83–104.
[34] L. Hu, P.M. Bentler, Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives, Struct. Equ. Modell. 6 (1999) 1–55.
[35] WHO, A Conceptual Framework for Action on the Social Determinants of Health, World Health Organization, Geneva, Switzerland, 2010.
[36] M. Furuta, D. Ekuni, S. Takao, E. Suzuki, M. Morita, I. Kawachi, Social capital and self-rated oral health among young people, Community Dent. Oral Epidemiol. 40 (2012) 97–104.
[37] H. Fontanini, Z. Marshman, M. Vettore, Social support and social network as intermediary social determinants of dental caries in adolescents, Community Dent. Oral Epidemiol. 43 (2015) 172–182.
[38] A.N. Donaldson, B. Everitt, T. Newton, J. Steele, M. Sherriff, E. Bower, The effects of social class and dental attendance on oral health, J. Dent. Res. 87 (2008) 60–64.
[39] X.L. Gao, C.Y. Hsu, Y.C. Xu, T. Loh, D. Koh, H.B. Hwarng, Behavioral pathways explaining oral health disparity in children, J. Dent. Res. 89 (2012) 985–990.
[40] S. Nelson, W. Lee, J.M. Albert, L.T. Singer, Early maternal psychosocial factors are predictors for adolescent caries, J. Dent. Res. 91 (2012) 859–864.
[41] G. Ekbäck, S. Ordell, Does different wording of a global oral health question provide different results? Acta Odontol. Scand. 73 (2015) 250–257.
[42] T.Z. Insaf, B.A. Shaw, R.M. Yucel, L. Chasan-Taber, D.S. Strogatz, Lifecourse socioeconomic position and 16 year body mass index trajectories: differences by race and sex, Prev. Med. 67 (2014) 17–23.
[43] P.E. Gustafsson, U. Janlert, T. Theorell, H. Westerlund, A. Hammarström, Socioeconomic status over the life course and allostatic load in adulthood: results from the Northern Swedish Cohort, J. Epidemiol. Community Health 65 (2011) 986–992.
[44] D. Kuh, Y. Ben-Shlomo, J. Lynch, C. Hallqvist, C. Power, Life course epidemiology, J. Epidemiol. Community Health 57 (2003) 778–783.