

Socioeconomic disadvantage across the life-course and oral health in older age: findings from a longitudinal study of older British men

Sheena E. Ramsay,^{1,2} Efstathios Papachristou,² Richard G. Watt,³ Lucy T. Lennon,² A. Olia Papacosta,² Peter H. Whincup,⁴ S. Goya Wannamethee²

¹Institute of Health & Society, Newcastle University, Newcastle upon Tyne, United Kingdom

²Institute of Epidemiology and Health Care, UCL, London, United Kingdom

³Department of Epidemiology & Public Health UCL, London, United Kingdom

⁴Population Health Research Institute, St George's University of London, London, United Kingdom

Correspondence to:

Dr Sheena E. Ramsay, Institute of Health & Society, Newcastle University, The Baddiley-Clark Building, Richardson Road, Newcastle upon Tyne NE2 4AX, United Kingdom

Email: sheena.ramsay@newcastle.ac.uk

ABSTRACT

Background: The influence of life-course socioeconomic disadvantage on oral health at older ages is not well-established. We examined the influence of socioeconomic factors in childhood, middle-age and older age on oral health at older ages, and tested conceptual life-course models (sensitive period, accumulation of risk, social mobility) to determine which best described observed associations.

Methods: A representative cohort of British men aged 71-92 in 2010-12 included socioeconomic factors in childhood, middle-age and older age. Oral health assessment at 71-92 years (n=1622) included tooth count, periodontal disease, and self-rated oral health (excellent/good, fair/poor) (n=2147). Life-course models (adjusted for age and town of residence) were compared with a saturated model using Likelihood-ratio tests.

Results: Socioeconomic disadvantage in childhood, middle-age and older age was associated with complete tooth loss at 71-92 years – age and town adjusted odds ratios (95%CI) were 1.39 (1.02-1.90), 2.26 (1.70-3.01), 1.83 (1.35-2.49) respectively. Socioeconomic disadvantage in childhood and middle-age was associated with poor self-rated oral health; adjusted odds ratios (95%CI) were 1.48 (1.19-1.85) and 1.45 (1.18-1.78) respectively. A sensitive period for socioeconomic disadvantage in middle-age provided the best model fit for tooth loss, while accumulation of risk model was strongest for poor self-rated oral health. None of the life-course models were significant for periodontal disease measures.

Conclusion: Socioeconomic disadvantage in middle-age has a particularly strong influence on tooth loss in older age. Poor self-rated oral health in older age is influenced by socioeconomic disadvantage across the life-course. Addressing socioeconomic factors in middle and older ages are likely to be important for better oral health in later life.

Keywords: life-course, socioeconomic disadvantage, oral health, older age.

INTRODUCTION

Oral diseases are among the most prevalent chronic health conditions and pose a significant public health challenge in countries with rapidly ageing populations.¹ Tooth loss, periodontal (gum) disease, dental caries and dry mouth (xerostomia) increase substantially with age.² These oral health problems affect nutritional intake, result in oral infections, pain and ulcers, and adversely affect daily activities such as eating and speaking.^{1,2}

Oral health is also known to have marked socioeconomic inequalities, with greater tooth loss, dental caries and periodontal disease in those with greater socioeconomic disadvantage.³⁻⁸ A key question for reducing these inequalities is to understand which stages of the life-course are most important in defining the socioeconomic differences.⁹⁻¹¹ Briefly, life-course epidemiological hypotheses include sensitive period, social mobility and accumulation of risk models.¹⁰ According to the sensitive period model, certain stages of the life-course have a strong effect on disease risk. The social mobility hypotheses suggests upward or downward mobility in socioeconomic position across the life-course is associated with a decreased or increased risk of disease. Finally, the accumulation of risk model states that exposures across the life-course have a cumulative effect on increased risk of disease later in life. Studies applying a life-course perspective to oral health have found that social disadvantage in childhood is associated with periodontal disease and tooth retention in adulthood.^{12, 13} Prolonged exposure to lower socioeconomic position, as well as upward and downward social mobility, is found to influence periodontal disease, poor self-rated oral health and poor tooth retention in middle-age.¹⁴

However, relatively little is known about the influence of life-course socioeconomic factors on oral health in older age;^{12, 15} studies so far are largely in younger and middle-aged populations.^{13, 14, 16, 17} A study in Swedish and Norwegian cohorts found that socioeconomic conditions both in early adulthood and later life had independent effects on self-reported tooth loss in older age.¹² However, the evidence for the influence of socioeconomic conditions at different stages of the life-course (early, middle and late) on oral health outcomes such as periodontal disease and self-rated oral health is limited. In this study, we use a life-course approach to assess the impact of socioeconomic factors in childhood, middle-age (40-59 years) and older age (60-79 years) on a range of subjective and objective oral health measures assessed at age 71-92 years in a representative cohort of older British men. Using a structured modelling approach we examine

three life-course hypotheses, including sensitive periods, social mobility and accumulation of risk to identify outcome-specific relationships between socioeconomic disadvantage and oral health.

METHODS

The British Regional Heart Study is a prospective study comprising a socially and geographically representative sample of 7735 men aged 40-59 from one general practice in each of 24 towns representing all major British regions, initiated in 1978- 1980.^{18 19} In 2010-2012 all surviving men (n=3,137) aged 71-92 were invited to attend the 30-year re-examination. Ethical approval was provided by all relevant local research ethics committees. All men provided written informed consent to the investigations, which were carried out in accordance with the Declaration of Helsinki. This paper follows STROBE guidelines.

Childhood socioeconomic position was based on the father's longest-held occupation; participants were classified into non-manual and manual childhood socioeconomic groups using the Office of Population Censuses and Surveys Classification of Occupations (1980) social class coding index manual.²⁰

Socioeconomic disadvantage in middle-age was based on participants' longest-held occupation of recorded at study entry aged 40-59 years and classified using the Registrar Generals' Social Class Classification. Social class groups I (professionals, e.g. physicians, engineers), II (managerial, e.g. teachers, sales managers), III non-manual (semi-skilled non-manual, e.g. clerks, shop assistants) were grouped as non-manual, and social classes III manual (semi-skilled manual, e.g. bricklayers), IV (partly skilled, e.g. postmen) and V (unskilled, e.g. porters, general labourers) were grouped as manual.

Socioeconomic disadvantage in older age (60-79 years) was based on the Index of Multiple Deprivation (IMD) for England (2004), Scotland (2004), and Wales (2005).²¹ IMD is a composite measure of deprivation comprising income, employment, health and disability, education, skills and training, barriers to housing and services, living environment and crime. IMD scores are collected at aggregate level for small geographical units called lower super output areas (LSOA) (average of 1500 people); small area units in Scotland are 'Data Zones' (average of 750 people).

IMD scores for LSOAs were linked with participants' postcodes of residence at 60-79 years and divided into quintiles from the least to the most deprived quintile.²¹

Oral health outcomes in later life

Oral health measures were assessed during the 30-year re-examination in 2010-2012 when participants were aged 71-92 years.²² Overall self-rated oral health was assessed through questionnaires in which participants were asked to rate their oral health as excellent, good, fair, or poor. Objective oral health measures included number of teeth, and measures of periodontal disease on six index teeth (one in each sextant), including periodontal pocket depth and loss of attachment. Loss of attachment was assessed at two sites (mesiobuccal and distobuccal sites) on index teeth, and periodontal pocket depth was measured on the mesiobuccal site. A CPITN (Community Periodontal Index of Treatment Needs) probe with a 0.5mm ball-ended tip with markings at 0 to 3.5mm, >3.5mm to 5.5mm, and >5.5mm was used. Examiners underwent extensive training and calibrations including a pilot prior to the study and a calibration check during the study. Agreement between examiners and the training examiner ranged from 89% to 95%.²²

Statistical Analysis

Using logistic regression models we calculated odds ratios adjusted for age and town of residence to examine the relationships between socioeconomic disadvantage and oral health at 71-92 years independently for childhood, middle-age (40-59 years) and older age (60-79 years). The measures of oral health outcomes were from the physical examination of the cohort at age 71-92 years. Oral health outcomes included no natural teeth (edentulism), <21 teeth (21 teeth as the minimum required for functional dentition), fair/poor self-rated oral health, and two measures of periodontal disease (more than 20% sites affected by periodontal pockets >3.5mm; and more than 20% sites affected by loss of attachment >5.5mm). To investigate socioeconomic disadvantage across the life-course, trajectories were defined according to whether an individual was in a disadvantaged group (1) or not (0) at each stage (childhood, middle-age, older age) and trajectories were denoted by triplets of zeros and ones. To allow sufficient numbers in the trajectories, the measures of socioeconomic disadvantage were categorised as binary variables (manual vs non-manual father's social class for childhood; manual vs non-manual own social class for middle-age; lowest two quintiles of deprivation (most deprived quintiles) vs rest for older age).

Logistic regression models were used to examine the effect of each trajectory on oral health outcomes [reference category as those who were not in a disadvantaged group throughout the three life-course stages (“0-0-0” trajectory)]. Age and town of residence were adjusted for as fixed effects. Using a structured modelling approach for binary outcomes²³, we also tested which of the accumulation, sensitive period and social mobility life-course hypotheses underlies the relationship between socioeconomic disadvantage and oral health outcomes. Each model was conceptualized as a special case of the saturated model which includes the regression coefficients of all trajectories, as well as their two-way interactions and their three-way interactions²³. Simpler models corresponding to the life-course hypotheses were compared to the saturated model using likelihood-ratio tests (LR-tests) to examine whether these simpler models fitted the data equally well. The highest *p*-value for a life-course model was chosen as the best-fitting model for each oral health outcome. Additionally, the best-fitting life-course model for that particular oral health outcome was adjusted for body mass index (BMI measured at follow-up physical examinations of study participants) (≥ 30 kg/m² for obesity), and smoking status (smoker vs. non-smoker) across adulthood using logistic regression in order to examine whether these covariates explained the association between socioeconomic disadvantage and oral health. These variables were included since these are strongly socially patterned and associated with poor oral health.^{24 25} Covariates included obesity and smoking status at 71-92, 40-59 years and 60-79 years, and were added to regression models in turn and all together. Analyses were performed using Stata/SE 14 (Stata Corp, College Station, TX, USA).

RESULTS

The follow-up of the BRHS cohort at 71-92 years included 2,137 participants (68% response rate). Of these, 1,903 study participants had complete data on socioeconomic factors in childhood, middle-age (ages 40-59 years) and older age (ages 60-79 years). Table 1 summarizes the characteristics of this cohort at age 71-92 years when the outcome measures were assessed. Sensitivity analyses showed that subjects who participated in the 30-year re-examination of the BRHS at age 71-92 years in 2010-2012 but did not have complete data on socioeconomic disadvantage at different stages of the life-course (*n*=234), did not differ from those with complete data in terms of their current socioeconomic factors (*p*=0.80), current smoking (0.08), or mean body mass index (BMI) levels (*p*=0.13).

Table 2 presents odds ratios (95%CI) for oral health outcomes at 71-92 years according to socioeconomic disadvantage in childhood, middle-age and older age from logistic regression models adjusted for age and town of residence. Socioeconomic disadvantage during either childhood or middle-age was associated with significantly higher risks of tooth loss and poor self-rated oral health at 71-92 years (Table 2). Additionally, socioeconomic disadvantage during childhood was associated with a higher risk of greater loss of periodontal attachment. Socioeconomic disadvantage in older age (60-79 years) was also associated with a higher risk of tooth loss. Socioeconomic disadvantage at any stage was not significantly associated with increased periodontal pocket depth at 71-92 years (Table 2).

Table 3 shows the associations between trajectories of socioeconomic disadvantage across the life-course (childhood, middle-age, older age) and adverse oral health outcomes at 71-92 years. Compared to those who were never in a disadvantaged group at any stage (trajectory "0-0-0"), those in socioeconomically disadvantaged groups in childhood and middle-age (trajectory "1-1-0"), and in middle-age and older age (trajectory "0-1-1"), as well as in all three stages (trajectory "1-1-1"), had a significantly higher risk of tooth loss (no teeth, and <21 teeth) and poor self-rated oral health at 71-92 years (Table 3). Moreover, socioeconomic disadvantage in middle-age alone (trajectory "0-1-0") was significantly associated with tooth loss, while socioeconomic disadvantage in childhood and middle-age (trajectory "1-1-0") was significantly associated with greater loss of attachment (Table 3).

Table 4 shows results of the LR-tests comparing each life-course model against the saturated model. Middle-age as a sensitive period provided the best model fit for both outcomes of tooth loss at 71-92 years (<21 teeth $p=0.20$; and no teeth $p=0.16$). In contrast, poor self-rated oral health at 71-92 years was best explained by the accumulation of risk model; specifically, accumulation of socioeconomic disadvantage across all stages of the life-course best explained the increased risk for poor self-rated oral health ($p=0.37$). Trajectories of socioeconomic disadvantage were not, however, predictive of periodontal pocket depth ($p=0.44$) or loss of attachment ($p=0.38$) at 71-92 years.

The best-fitting life-course models observed for tooth-loss and self-rated oral health are presented in Table 5 with further adjustments for obesity and smoking status across adulthood. Socioeconomic disadvantage in middle-age remained a significant predictor of both outcomes of tooth loss at 71-92 years after adjustments for the covariates. Similarly, the cumulative risk of socioeconomic disadvantage across childhood, middle-age and older age was slightly attenuated, yet remained highly significant after adjustments for all covariates (all p-values \leq 0.007).

DISCUSSION

Main finding of this study

In our study of a representative cohort of older British men using novel life-course analytical approaches, we found that socioeconomic disadvantage in middle-age was particularly associated with higher levels of edentulism and absence of a functional dentition (<21 natural teeth) in older age (71-92 years). Socioeconomic disadvantage across childhood, middle-age and later in life, reflecting an accumulation of risk, was important for poor self-rated oral health in older age. These findings highlight the importance of socioeconomic factors at different stages of the life-course on oral health in older age.

What is already known on this topic

Comparison with previous studies

Previous studies have shown that socioeconomic disadvantage is associated with periodontal disease, tooth loss and poor-self rated oral health.³⁻⁷ Life-course approaches have been applied to understand the importance of socioeconomic determinants at different stages of the life-course on oral health in adulthood.^{26 12-14 17 27 28} However, these studies comprised younger and middle-aged adults and very few studies have investigated the role of life-course socioeconomic factors on oral health in older ages.^{12 15}

What this study adds

To our knowledge, the present study is the first to investigate whether a range of oral health measures in older adults aged >70 years are influenced by life-course socioeconomic factors across childhood, middle-age and old age. We used a novel structured modelling approach used previously for chronic diseases,^{23 29 30} in order to identify life-course models (sensitive period, accumulation of risk and social mobility) that are important for oral health outcomes of tooth loss,

self-rated oral health and periodontal disease in older ages. We observed that different life-course models explained the relationships between socioeconomic disadvantage and different oral health outcomes. Middle-age appeared to be a sensitive period of exposure to socioeconomic disadvantage for tooth loss in older age – both complete tooth loss and presence of a functional dentition at 71-92 years. The influence of middle-age socioeconomic disadvantage was independent of lifestyle factors across adulthood including BMI and smoking. It is possible that our study underestimated the mediating role of smoking due to loss to follow-up of participants who smoked and had higher mortality rates. Contrary to our findings, a study of Swedish and Norwegian older adults observed that socioeconomic conditions in early (at birth) and later life (age 65 years) were strong predictors of tooth loss at age 70.¹² However, that study used a broad measure of social conditions including marital status and social network which were not part of our measures of socioeconomic disadvantage. Another study based on a similar sample of Swedish older adults found that accumulation of adverse social conditions in later life (ages 50 and 65 years) were associated with greater levels of tooth loss and poor self-perceived oral health.¹⁵ In our study we also found support for the accumulation of risk model for poor-self rated oral health – social disadvantage in childhood, middle-age and older age act in a cumulative fashion to increase the risk of poor-self rated oral health at 71-92 years. This was also independent of obesity and smoking status across adulthood. We found little support for the importance of any life-course model on periodontal disease at age 71-92 years. While previous studies comprising younger or middle-aged populations have shown some evidence for an association between early life socioeconomic factors and periodontal disease,³¹ it is possible that these associations are diminished by older age. The absence of an association of socioeconomic disadvantage with periodontal disease in our study of older men could be because of healthy survivor effects such that the teeth with greater periodontal disease would have been lost by this age, as well as the likelihood that participants from lower socioeconomic groups with higher levels of periodontal disease and related risk factors, predominantly smoking, had died earlier during the follow-up.

Strengths and limitations of this study

A particular strength of our study is the detailed investigation of life-course effects of socioeconomic disadvantage on oral health in older age in a socially and geographically representative study of older British men with unique data on socioeconomic factors in childhood, middle-age as well as older ages. We also applied a structured modelling approach to examine the

best-fitting life-course models that explains the relationship between socioeconomic disadvantage and oral health.²³ Our study included a range of oral health measures including objectively assessed tooth count and periodontal disease, and self-rated oral health which is a strong summary marker of oral disease and health.³²⁻³⁶ We also acknowledge limitations in our study. Our study comprised men who were predominantly white European and our findings may not be completely generalizable to women and other ethnic groups. It is possible that different life-course models may underlie poor oral health in women; previous studies suggest that accumulation of socioeconomic disadvantage had stronger effects on tooth retention in women than in men,¹⁷ while social mobility models were more important for periodontal disease in women than in men.²⁸ We used a measure of socioeconomic disadvantage in older age (60-79 years) based on a composite measure of deprivation, which was different to that at middle-age (40-59 years) based on occupational social class. Although this measure of disadvantage is not entirely comparable with earlier occupation-based measures, correlation coefficients between the measures were statistically significant. Although we had high response rates for the follow-up at 71-92 years (68% for questionnaires), it is possible that those with worse general and oral health did not respond, particularly at the physical examination which had a lower response rate of 55%. The results are likely to underestimate socioeconomic differences since non-responders are more likely to be from lower socioeconomic groups and have worse health conditions. While we considered the role of obesity and smoking in adulthood as mediators of relationships between life-course socioeconomic factors and oral health in later life, we were unable to examine the contribution of other potential mediators such as nutrition (particularly sugar intake), and access to dental services across the life-course. We did not have information on oral health in childhood and middle-age and therefore, could not take into account the role of oral health earlier in life on poor oral health in older age. We were unable to investigate the influence of life-course socioeconomic disadvantage on dental caries (tooth decay) due to lack of these data in our study.

Implications and conclusions

Our findings provide new and important evidence for the persisting influence of socioeconomic factors across the life-course on poor oral health in older age. Socioeconomic factors across the life-course will be important in improving these oral health outcomes in older people. Further research is needed to understand how socioeconomic factors impact on poor oral health in older age, whether through poor nutrition, or access to dental services, or a tracking of poor oral health

from early in life.³⁷ With an increasingly growing number of older people, it is important to reduce the burden of poor oral health of ageing populations. This study provides the basis for greater policy efforts to address socioeconomic disadvantage across the life-course in order to improve the oral health of older people.

Funding: The British Regional Heart Study was supported by a British Heart Foundation Programme Grant (RG/08/013/25942), the Dunhill Medical Trust (R396/1114); and the UK MRC (G1002391). The views expressed in this paper are those of the authors and not necessarily those of the funding bodies.

Competing interests: None.

REFERENCES

1. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. *Community dentistry and oral epidemiology* 2005;33:81-92.
2. Thomson WM. Epidemiology of oral health conditions in older people. *Gerodontology* 2014;31:9-16.
3. Thomson WM, Sheiham A, Spencer AJ. Sociobehavioral aspects of periodontal disease. *Periodontology 2000* 2012;60(1):54-63.
4. Tsakos G, Demakakos P, Breeze E, et al. Social Gradients in Oral Health in Older Adults: Findings From the English Longitudinal Survey of Aging. *American Journal of Public Health* 2011;101(10):1892-99.
5. Sabbah W, Tsakos G, Chandola T, et al. Social gradients in oral and general health. *J Dent Res* 2007;86:992-96.
6. Watt R, Sheiham A. Inequalities in oral health: a review of the evidence and recommendations for action. *Br Dent J* 1999;187(1):6-12.
7. Mejia G, Armfield JM, Jamieson LM. Self-rated oral health and oral health-related factors: the role of social inequality. *Australian Dental Journal* 2014;59(2):226-33.
8. Schwendicke F, Dorfer CE, Schlattmann P, et al. Socioeconomic inequality and caries: a systematic review and meta-analysis. *J Dent Res* 2015;94(1):10-8.
9. Papachristou E, Frangou S, Reichenberg A. Expanding conceptual frameworks: Life course risk modelling for mental disorders. *Psychiatry Res* 2013;206(2):140-45.
10. Ben-Shlomo Y, Kuh D. A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives. *International Journal of Epidemiology* 2002;31:285-93.
11. Kuh D, Ben-Shlomo Y, Lynch J, et al. Life course epidemiology. *J Epidemiol Community Health* 2003;57(10):778-83.
12. Gulcan F, Ekback G, Ordell S, et al. Inequality in oral health related to early and later life social conditions: a study of elderly in Norway and Sweden. *BMC Oral Health* 2015;15(1):20.
13. Nicolau B, Netuveli G, Kim JW, et al. A life-course approach to assess psychosocial factors and periodontal disease. *J Clin Periodontol* 2007;34(10):844-50.
14. Bernabe E, Suominen AL, Nordblad A, et al. Education level and oral health in Finnish adults: evidence from different lifecourse models. *J Clin Periodontol* 2011;38(1):25-32.
15. Åstrøm AN, Ekback G, Lie SA, et al. Life-course social influences on tooth loss and oral attitudes among older people: evidence from a prospective cohort study. *European Journal of Oral Sciences* 2015;123(1):30-38.

16. Pearce MS, Steele JG, Mason J, et al. Do Circumstances in Early Life Contribute to Tooth Retention in Middle Age? *Journal of Dental Research* 2004;83(7):562-66.
17. Pearce MS, Thomson WM, Walls AWG, et al. Lifecourse Socio-economic Mobility and Oral Health in Middle Age. *Journal of Dental Research* 2009;88(10):938-41.
18. Walker M, Whincup PH, Shaper AG. The British Regional Heart Study 1975-2004. *Int J Epidemiol* 2004;33:1185-92.
19. Lennon LT, Ramsay SE, Papacosta O, et al. Cohort Profile Update: The British Regional Heart Study 1978–2014: 35 years follow-up of cardiovascular disease and ageing. *International Journal of Epidemiology* 2015;44(3):826-26g.
20. Wannamethee SG, Whincup PH, Shaper G, et al. Influence of fathers' social class on cardiovascular disease in middle-aged men. *The Lancet* 1996;348:1259-63.
21. Ramsay SE, Morris RW, Whincup PH, et al. The influence of neighbourhood-level socioeconomic deprivation on cardiovascular disease mortality in older age: longitudinal multilevel analyses from a cohort of older British men. *Journal of Epidemiology and Community Health* 2015;69:1224-31. doi:
22. Ramsay SE, Whincup PH, Watt RG, et al. Burden of poor oral health in older age: findings from a population-based study of older British men. *BMJ Open* 2015;5(12):e009476.
23. Mishra G, Nitsch D, Black S, et al. A structured approach to modelling the effects of binary exposure variables over the life course. *International Journal of Epidemiology* 2009;38:528-37.
24. Dietrich T, Walter C, Oluwagbemigun K, et al. Smoking, Smoking Cessation, and Risk of Tooth Loss: The EPIC-Potsdam Study. *Journal of Dental Research* 2015;94(10):1369-75.
25. Pischon N, Heng N, Bernimoulin JP, et al. Obesity, Inflammation, and Periodontal Disease. *Journal of Dental Research* 2007;86(5):400-09.
26. Nicolau B, Thomson WM, Steele JG, et al. Life-course epidemiology: concepts and theoretical models and its relevance to chronic oral conditions. *Community dentistry and oral epidemiology* 2007;35(4):241-9.
27. Mason J, Pearce MS, Walls AWG, et al. How Do Factors at Different Stages of the Lifecourse Contribute to Oral-health-related Quality of Life in Middle Age for Men and Women? *Journal of Dental Research* 2006;85(3):257-61.
28. Shin BM, Ryu JI, Sheiham A, et al. Which life course model better explains the association between socioeconomic position and periodontal health? *J Clin Periodontol* 2015;42(3):213-20.
29. Kapetanakis VV, Rudnicka AR, Wathern AK, et al. Adiposity in early, middle and later adult life and cardiometabolic risk markers in later life; findings from the British regional heart study. *PLoS One* 2014;9(12):e114289.
30. Jones R, Hardy R, Sattar N, et al. Novel coronary heart disease risk factors at 60–64 years and life course socioeconomic position: The 1946 British birth cohort. *Atherosclerosis* 2015;238(1):70-76. doi:
31. Schuch HS, Peres KG, Singh A, et al. Socioeconomic position during life and periodontitis in adulthood: a systematic review. *Community dentistry and oral epidemiology* 2016;45:201-208
32. Locker D, Wexler E, Jokovic A. What do older adults' global self-ratings of oral health measure? *J Public Health Dent* 2005;65(3):146-52.
33. Gilbert GH, Duncan RP, Heft MW, et al. Multidimensionality of oral health in dentate adults. *Med Care* 1998;36(7):988-1001.
34. Jones JA, Kressin NR, Spiro A, 3rd, et al. Self-reported and clinical oral health in users of VA health care. *J Gerontol A Biol Sci Med Sci* 2001;56(1):M55-62.
35. Pattussi MP, Peres KG, Boing AF, et al. Self-rated oral health and associated factors in Brazilian elders. *Community dentistry and oral epidemiology* 2010;38(4):348-59.]
36. Wu B, Plassman BL, Liang J, et al. Differences in self-reported oral health among community-dwelling black, Hispanic, and white elders. *J Aging Health* 2011;23(2):267-88.
37. Broadbent JM, Zeng J, Foster Page LA, et al. Oral Health-related Beliefs, Behaviors, and Outcomes through the Life Course. *J Dent Res* 2016;95(7):808-13.

Table 1: Characteristics of the British Regional Heart Study cohort of men aged 71-92 years from 24 British towns

	Overall
n (%)	1,903 (100%)
Age, mean (SD) in years	77 (4.8)
<21 teeth - n (%)	939 (64%)
No teeth - n (%)	295 (20%)
Poor self-reported oral health - n (%)	638 (35%)
More than 20% sites affected by periodontal pockets>3.5mm - n (%)	332 (30%)
More than 20% sites affected with loss of attachment>5.5mm - n (%)	271 (24%)
Socioeconomic disadvantage in childhood - n (%)	
Non-manual father's social class	1300 (68%)
Manual father's social class	603 (32%)
Socioeconomic disadvantage in middle-age (40-59 years) – social class groups - n (%)	
I Professional	233 (12%)
II Managerial	570 (30%)
III Non-Manual	199 (10%)
III Manual	713 (37%)
IV Semi-Skilled	139 (7%)
V Unskilled	49 (3%)
Socioeconomic disadvantage in older age (60-79 years) by Indices of Multiple Deprivation at quintile - n (%)	
I (least deprived)	502 (26%)
II	509 (27%)
III	373 (20%)
IV	289 (15%)
V (most deprived)	230 (12%)
Smoking – n (%)	
Never Smoked	702 (37%)
Long term ex-smokers ^a	846 (45%)
Recent ex-smokers ^b	277 (15%)
Current smoker	76 (4%)
BMI, mean (SD) in kg/m²	27.14 (3.8)

^aGave up before 1983; ^bGave up before 2010-2012; ^cDefined as more than six units (1 UK unit = 10g) of alcohol daily or on most days.

Table 2. Age and town-adjusted odds ratios describing associations between oral health outcomes at 71-92 years in a British cohort of men and socioeconomic disadvantage in childhood, middle and older age

	<21 teeth	No teeth	Poor self-rated oral health	More than 20% sites affected by periodontal pockets>3.5mm	More than 20% sites affected with loss of attachment>5.5mm
Childhood socioeconomic disadvantage n (%) OR (95% CI) childhood manual vs non-manual groups	682 (69%) 1.62 (1.27-2.06)	222 (22%) 1.39 (1.02-1.90)	469 (38%) 1.48 (1.19-1.85)	233 (32%) 1.29 (0.95-1.75)	194 (27%) 1.39 (1.01-1.91)
Middle-age socioeconomic disadvantage (40-59 years) n (%) OR (95% CI) manual vs non-manual groups	499 (74%) 2.12 (1.67-2.70)	184 (27%) 2.26 (1.70-3.01)	334 (39%) 1.45 (1.18-1.78)	155 (33%) 1.16 (0.87-1.56)	131 (28%) 1.34 (0.99-1.81)
Older age socioeconomic disadvantage (60-79 years) n (%) OR (95% CI) bottom two deprived quintiles vs rest	284 (75%) 1.46 (1.09-1.95)	117 (31%) 1.83 (1.35-2.49)	192 (39%) 1.21 (0.96-1.54)	96 (39%) 1.12 (0.79-1.58)	72 (29%) 1.07 (0.75-1.54)

Table 3. Age and town adjusted odds ratios describing associations between oral health outcomes at ages 71-92 years and life-course trajectories of socioeconomic disadvantage in a cohort of 1,903 British men

Trajectories of socioeconomic disadvantage (childhood, middle-age, older age)*	n (%)	<21 teeth	No teeth	Poor self-reported oral health	More than 20% sites affected by periodontal pockets>3.5mm	More than 20% sites affected with loss of attachment>5.5mm
0-0-0	403 (21%)	ref	ref	ref	ref	ref
1-0-0	442 (23%)	1.34 (0.97-1.85)	1.35 (0.83-2.19)	1.17 (0.86-1.59)	0.98 (0.65-1.48)	1.23 (0.80-1.90)
0-1-0	98 (5%)	2.07 (1.22-3.54)	2.31 (1.17-4.59)	0.95 (0.57-1.58)	0.63 (0.30-1.29)	1.40 (0.71-2.75)
0-0-1	56 (3%)	0.85 (0.43-1.68)	2.34 (1.03-5.31)	0.85 (0.43-1.66)	0.86 (0.36-2.03)	0.75 (0.28-2.00)
1-1-0	441 (23%)	2.38 (1.69-3.36)	2.51 (1.56-4.02)	1.75 (1.29-2.39)	1.30 (0.85-1.99)	1.58 (1.02-2.46)
1-0-1	101 (5%)	1.71 (0.96-3.03)	1.52 (0.73-3.17)	1.51 (0.92-2.47)	1.21 (0.63-2.32)	1.52 (0.77-2.99)
0-1-1	46 (2%)	2.79 (1.07-7.30)	4.42 (1.84-10.61)	1.45 (0.73-2.91)	0.75 (0.23-2.45)	0.87 (0.25-2.97)
1-1-1	316 (17%)	3.14 (2.04-4.84)	3.70 (2.25-6.08)	1.77 (1.25-2.51)	1.32 (0.80-2.17)	1.59 (0.94-2.68)

*Trajectories were based on whether an individual was in a disadvantaged group (1) or not (0) at each stage (childhood, middle-age, older age) and were denoted by triplets of zeros and ones

Table 4. P-values from likelihood-ratio tests comparing life-course models relating socioeconomic disadvantage and oral health outcomes with the saturated model in a sample of 1,903 British men*

Life-course model	<21 teeth	No teeth	Poor self-rated oral health	More than 20% sites affected by periodontal pockets >3.5mm	More than 20% sites affected with loss of attachment >5.5mm
No effect	<.001	<.001	0.002	0.44	0.38
Sensitive period models					
Childhood	<.001	<.001	0.10	0.65	0.77
Middle-age	0.20	0.16	0.11	0.44	0.70
Older age	<.001	<.001	0.002	0.37	0.29
Accumulation models					
Childhood and Middle-age	0.02	0.03	0.09	0.57	0.61
Middle-age and Older age	0.13	0.06	0.36	0.71	0.78
Whole life	0.17	0.11	0.37	0.69	0.75
Social Mobility Model					
Adulthood	<.001	<.001	0.002	0.25	0.39
Whole life	<.001	<.001	0.001	0.40	0.38

Bold indicates p-value >0.05.

*Larger p values represent better model fit. Shaded cells indicate the selected model - the most parsimonious model with a good fit to the data.

Table 5. Life-course models selected for tooth loss and self-rated oral health with odds ratios (95%CI) adjusted for obesity and smoking status across adulthood

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	Age and town of residence	Model 1 + Obesity ^a in middle-age (40-59 years)	Model 1 + Obesity ^a in older age (60-79 years)	Model 1 + Current obesity ^a (71-92 years)	Model 1 + Smoking in middle-age (40-59 years)	Model 1 + Smoking in older age (60-79 years)	Model 1 + Current smoking (71-92 years)	All
Middle-age sensitive period model (manual vs non-manual socioeconomic group in middle-age, 40-59 years)								
<21 teeth	2.12 (1.67-2.70)	2.12 (1.67-2.70)	2.01 (1.57-2.58)	2.07 (1.62-2.63)	2.03 (1.59-2.59)	2.01 (1.56-2.58)	2.10 (1.65-2.68)	1.87 (1.45-2.41)
No teeth	2.26 (1.70-3.01)	2.27 (1.70-3.02)	2.20 (1.63-2.96)	2.26 (1.69-3.01)	2.09 (1.56-2.81)	2.22 (1.64-3.00)	2.23 (1.67-2.98)	2.05 (1.50-2.80)
Accumulation model (each additional time in lower socioeconomic group in childhood, middle-age and older age)^b								
Poor self-rated oral health	1.26 (1.13-1.40)	1.26 (1.13-1.40)	1.24 (1.11-1.39)	1.26 (1.11-1.43)	1.24 (1.11-1.38)	1.23 (1.10-1.38)	1.25 (1.13-1.40)	1.20 (1.05-1.37)

^aObesity defined as body mass index ≥ 30 kg/m²

^bLinear trend across ordered categories presented as odds ratio (95% confidence interval)