Socio-economic position and oral health: comparing proximal and distal indicators

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Social inequalities in oral health are universal. Data collected to date has primarily been within the epidemiological tradition; identifying and quantifying risk factors for description and not explanation. Within this approach each risk factor is treated as occurring in the same temporal space or 'etiologic period'. By not taking into account temporal hierarchies, under- estimation of those factors further 'back' (i.e. distal) may have occurred. This study aimed to demonstrate the implication of modelling temporal considerations when analysing social determinants in oral health using a nationally representative sample (N = 3815). Structural equation modelling indicated that adopting the standard epidemiological approach to oral health inequalities would have led to misleading results; that is, no significant effect of education. In the sequential model, education had indirect effects on oral health via social class and income. There were no significant differences in model fit between gender and age groups; however, the multi-group analysis did indicate that for the younger group, education had a direct effect on oral health, whilst this was not the case for the older group. The findings support the shift within oral social epidemiology research to a life course approach.

Keywords: Oral health quality of life, structural equation modelling, socio-economic position, life-course, health inequalities

INTRODUCTION

Social inequalities in oral health are universal (Petersen *et al.*, 2005) and have been found in relation to a range of both clinical and patient-reported oral health outcomes (e.g. Donaldson *et al.*, 2008; Sabbah *et al.*, 2008; Sanders *et al.*, 2006a, 2006b). Such social gradients in oral health mirror those in general health (Marmot and Wilkinson, 2006).

At present, we do not have convincing explanations for such inequalities (Marmot, 2005). This may partly be because data collected to date has primarily been within the epidemiological tradition; identifying and quantifying risk factors for description and not explanation (Forbes and Wainwright, 2001). This approach entails collecting data on one or more indicators of socio-economic position (SEP) (typically education, occupation or income) and examining their relationship with health by way of standard regression models. In such models, one or more of the SEP variables is adjusted for, and the results compared with, models not adjusting for these variables. In terms of explaining social inequalities, this is a very blunt tool. It allows researchers to analyse the direct effect of each of the SEP indicators whilst holding the others constant. It does not, however, allow for the examination of the multiplicative nature of the predictors nor the influence of any intermediate variables (i.e. mediated effects). Moreover, by treating each of the risk factors as occurring in the same temporal space or 'etiologic period' (Krieger *et al.*, 1997), under-estimation of those further 'back' (i.e. distal) may occur because temporal hierarchies have not been taken into account (Weitkunat and Wildner, 2002).

This notion of proximal and distal factors is relatively uncommon in (oral) epidemiology. In relation to health generally, there is some evidence to suggest that SEP indicators are not on an equal temporal plane (Singh-Manoux *et al.*, 2002). These authors found that the causal and temporal ordering of SEP indicators was important; distal measures (education) influenced health both directly and indirectly through more proximal measures (occupation and income). Interestingly, whilst the direct effect of education on health was negative (i.e. better education was linked to poorer psychosocial health), the indirect effect was positive. These findings support the suggestion that risk factors are not 'independent' and that not taking into account these links would have led to misleading conclusions.

Such an approach would fit within a life-course perspective to chronic oral conditions that has been advanced recently (Nicolau *et al.*, 2007). The life-course approach suggests that risk factors do not occur in isolation, rather such factors are in complex chains over long periods of time and these may be proximal or distal to health outcomes. Yet, of the empirical studies to date (e.g. Sabbah *et al.*, 2008; Sanders *et al.*, 2006a, 2006b), few have taken account of temporal hierarchies within the life-course (Bernabe *et al*., 2009).

The primary aim of the present paper was to demonstrate the implication of modelling temporal considerations when analysing social determinants in oral health. Rather than using separate multivariate analyses to test such hierarchical frameworks, it is now possible to examine models with a range of distal and proximal determinants simultaneously using structural equation modelling with latent variables (SEM); a technique particularly suited to a life course approach (Newton and Bower, 2005). SEM also enables examination of multi-group models; that is, how the model differs according to group membership such as gender or age. The traditional epidemiological approach has been to control for these factors; neglecting the point that these may be important in understanding the complex pathways by which social factors influence health. There has been some suggestion, in relation to health generally, that SEP shapes gender disparities in health (e.g. Krieger *et al*., 1997; Moss, 2002). This may also be the case for age effects in chronic health conditions and functional status (House *et al*., 1990). Given that women and older age groups have been found to be at higher risk of oral ill-health (Riley and Gilbert, 2001), the secondary aim of the present paper was to test whether variations in the social gradient were similar across age groups and gender.

MATERIALS AND METHOD

Sample

All those participants in the 1998 UK Adult Dental Health (ADH) Survey (Kelly *et al*., 2000) who provided complete data for the Oral Health Impact Profile-short form (OHIP14) and had a dental examination were included (n = 3,815). Of the 3,815 participants (1,744 men, 2,071 women), the mean age was 43.16 years (SD = 16.39, Range = 16-95).

Measures

The following variables had missing values (numbers in parentheses are the number of participants for whom data was missing); OHIP physical sub-scale (1), OHIP psychological sub-scale (1), qualifications (1), income (303) and social class (210). In all cases, the missing data were substituted by the median for that item.

Education

Qualifications were assessed as the highest level of qualification received; 1 = degree level or above, 2 = below degree level and 3 = none.

Social class

Social class was measured according to the six-class Registrar General ranking but recoded for the purposes of the analysis into three categories; 1 = professional, management and technical, 2 = skilled non-manual and manual and 3 = partly skilled, unskilled and armed forces.

Income

Respondents picked a category that corresponded to their weekly gross joint household income. There were eight categories ranging from '<£100' to '>£700 or more'. For the purposes of the analysis, the categories were collapsed to four; 1 = £600+, 2 = under £600, 3 = under £400 and 4 = under £200.

Oral health

Clinician evaluated oral health was the number of decayed or unsound teeth derived at the clinical examination and based on the 1998 definition. Perceived oral health status was measured with the OHIP14 which assesses frequency of problems associated with the mouth or dentures (Slade, 1997). Participants are asked to rate for the last 3 months each item on a 5-point scale from 1 ("never") to 5 ("very often"). Three subscales were created representing the functional domains: physical (Items 1-4, 7, 8), social (Items 11-14) and psychological (Items 5, 6, 9, 10).

Statistical modelling procedure

The first step was to estimate two different models assessing the effects of SEP on the latent construct 'oral health'. Model I incorporated the three indicators of SEP as independent predictors of oral health (*Figure 1*: Paths a, b and c). These paths estimate the effect of each SEP whilst adjusting for the remaining measures. Observed variables are in rectangles, latent factors in ellipses and residual error terms in circles. Model II predicts temporal ordering between the indicators. Education is the distal measure, while social class and income are proximal measures. Education is predicted to have both a direct (Path d) and indirect effect on oral health. The indirect effect is hypothesised to be via three pathways; social class (Path ef), social class and income (Path egi) and income (Path hi) (see *Fig. 2*). If the temporal hypothesis is correct, Model II should allow a more complete explanation of the effects of SEP on oral health.

These models were examined using AMOS 7.0 (Arbuckle, 2007) and asymptotic distribution free (ADF) estimation with bootstrapping. ADF estimation can be used with ordinal or categorical indicators; ADF makes no distributional assumptions and can be employed when sample sizes are large (n = 1000+) (Muthen, 1993). Bootstrapping results in less biased estimates under conditions of nonnormality and for sample sizes ≥ 200 (Nevitt and Hancock, 2001) and is the best approach for testing indirect effects (McKinnon *et al*., 2002).

As recommended, model fit was evaluated using indices from the three fit classes. Absolute fit (χ^2/df ratio; standardised root mean squared residual (SRMR)), parsimony adjusted (root-mean-squared error of approximation (RMSEA) with 90% confidence intervals (90%CI)) and comparative (tucker-lewis index (TLI); comparative fit index (CFI)) (Hu and Bentler, 1999). A χ^2/df ratio < 3.0, RMSEA values < .06, CFI and TLI of .90 or above and an SRMR < .08 were taken to indicate an acceptable model fit (Hu & Bentler, 1999).

RESULTS

The means for each of the oral health indicators by the SEP measures can be seen in *Table 1*. As expected, there was a social gradient in both perceived and evaluated oral health.

Figure 1. Direct effects of education, social class and income on oral health (Model I). All figures are standardised bootstrap estimates. * p < .01, ** p < .001.

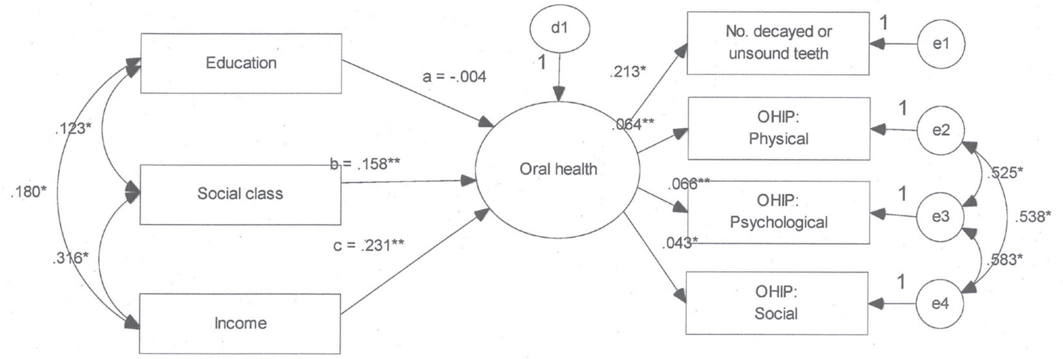

Figure 2. Direct and indirect effects of education, social class and income on oral health (Model II). All figures are standardised bootstrap estimates. * p < .01, ** p < .001.

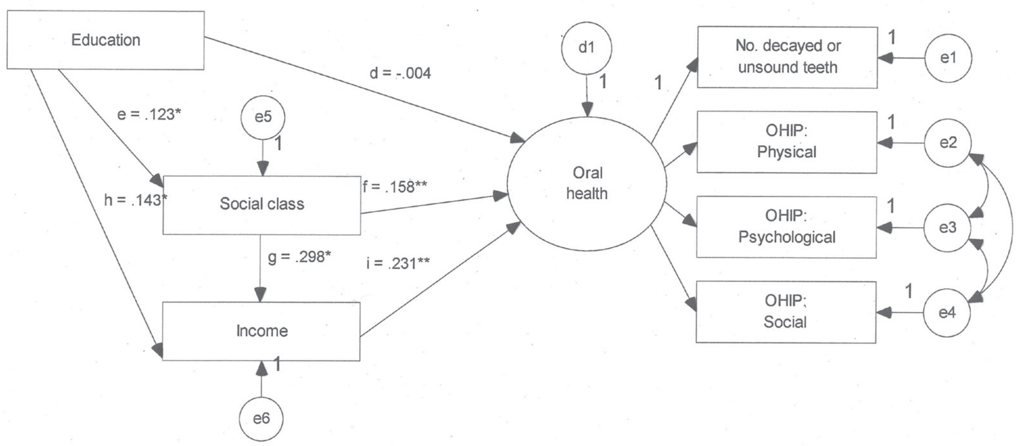

Table 1. Means of oral health indicators for socio-economic position measures.

	n	Physical Mean (SD)	OHIP Psychol Mean (SD)	Social Mean (SD)	No. of decayed or unsound teeth Mean (SD)
Education					
Above degree level	2361	3.80 (1.21)	2.65 (1.21)	2.20 (0.64)	1.45 (2.20)
Below degree level	648	3.64 (0.99)	2.50 (1.01)	2.16 (0.55)	1.13 (1.95)
None	806	3.95 (1.54)	2.78 (1.46)	2.22 (0.78)	1.64 (2.30)
Social Class					
Professional, managerial & technical	1257	3.76 (1.22)	2.60 (1.20)	2.20 (0.65)	1.20 (1.93)
Skilled manual & non-manual	1792	3.75 (1.19)	2.62 (1.19)	2.16 (0.57)	1.41 (2.11)
Partly skilled & unskilled	766	3.99 (1.44)	2.83 (1.42)	2.28 (0.84)	1.90 (2.66)
Income					
<£200	936	4.00 (1.58)	2.84 (1.48)	2.27 (0.85)	1.86 (2.48)
<£400	1270	3.78 (1.17)	2.60 (1.19)	2.17 (0.57)	1.48 (2.32)
<£600	787	3.73 (1.07)	2.63 (1.15)	2.19 (0.64)	1.30 (1.89)
£600+	822	3.69 (1.11)	2.55 (1.07)	2.16 (0.54)	1.03 (1.77)

SEP disparities in oral health: parallel or sequential?

The results of the SEM analysis indicated that both Models I and II were an excellent fit to the data on all of the a priori indices; χ^2/df (8) = .886 p = .527, TFI = 1.003, CFI = 1.000, SRMR = .008, RMSEA = .000 (90% CIs = .00-.02). Both models would be expected to be an equally good fit because they are equivalent SEM models (Kline, 2005). As can be seen in *Fig. 1*, in Model I (parallel model), education (Path a) did not directly predict oral health, whilst social class and income had significant direct effects (Paths b and c). Those individuals with lower social class and less income had more oral health impacts. The standardised coefficients reported in *Figure 1* indicate that an increase of one standard deviation in social class and income (indicating lower SEP) was associated with an increase of.158 and .231 standard deviation in oral health (indicating poorer oral health) respectively.

In Model II (sequential model), education had a significant indirect effect on oral health (Path d) (*Figure 2*). This represents a total indirect effect; that is, the sum of one or more specific paths. Specific indirect effects were:

- Education – social class – oral health (Path ef) (β = .019)
- Education – income – oral health (Path hi) (β = .033)
- Education – social class – income – oral health (Path egi) (β = .009).

The first pathway suggests that the impact of education on oral health was mediated by social class. This pathway accounted for 31.15% (.019/.061) of the total variance of the indirect effect between education and oral health. The second path incorporating income as the mediator accounted for 54.10% of the total indirect effect; whilst the third including both social class and income accounted for 14.75%.

SEP disparities in oral health: age or gender differences?

To examine whether there were differences in the effects of the SEP measures on oral health across groups, two SEM multi-group analyses were carried out (Arbuckle, 2007). The results indicated that for both Model I and II there was no difference between constrained (i.e. all estimates are assumed to be the same in males and females) and unconstrained models (i.e. all estimates were allowed to be different for males and females) (Model I = $\Delta\chi^2$ (3) = .173, ns; Model II = $\Delta\chi^2$ (6) = .702, ns). This indicates that men and women did not differ significantly with respect to the effects (direct or indirect) of SEP measures on oral health (*Table 2*).

For age groups, there was no significant difference in model fit between the constrained and unconstrained models (Model I = $\Delta\chi^2$ (3) = 1.117, ns); Model II = $\Delta\chi^2$ (6) = 3.736, ns). This indicates that both models were an equally good fit to the data. However, further inspection of individual parameter estimates (see *Table 2*) indicated that for the younger age group, the direct effect of education on oral health was significant, whilst for the older age group this was not the case. In the younger group, education did not predict social class (β = -.009) whilst for the older group it did (β = .206, $p < .001$).

DISCUSSION

The primary finding was that adopting the standard epidemiological approach to oral health inequalities led to misleading results. That is, in the parallel model, in which all SEP indicators were treated as equally proximate, education had no significant effect. In contrast, in the temporally sequential model, education had indirect effects on oral health via social class and/or income. A secondary finding was that the social gradient in oral health did not differ for men and women contrary to reports in the general health literature (Moss, 2002). Additionally, whilst there was no difference in overall model fit between the two age groups, with regard to individual pathways, for the younger group, education directly predicted oral health, whilst there was no significant direct effect of education for the older group. These data, whilst tentative, given that the analysis incorporated only two very broad age groups, suggest that further exploration of the age pathways through which social inequalities impact on oral health may be warranted.

The main point addressed in this paper is not original. However, the present data do support the one previous study using this type of temporal analysis with psychosocial health (Singh-Manoux *et al*., 2002), and extend these findings to oral health. As such, they suggest that the social gradient in oral health is sensitive to the aetiologic period of 'risk factors'. It may be that the assumption of parallel causation and the modelling of temporally mismatched data, may have led to erroneous relationships (e.g. distal factors underestimated) in oral epidemiology research (Sabbah *et al*., 2008; Sanders et al., 2006a, 2006b). Similarly, the trend toward the use of summative socio-economic disadvantage indicators (e.g. IRSD in Australia) may be insufficient in our attempt to understand health inequalities. As their name implies, such indices are summary statistics incorporating temporally mismatched indicators.

The present findings support the shift within social oral epidemiology research away from the decontextualised regression model to a contemporary life course perspective (Newton and Bower, 2005; Nicolas *et al*., 2007). This approach would not treat 'collinearity' between risk factors as an analytic problem to be controlled for but rather an interesting issue of interpretation (Der, 2001). Life-course epidemiologists need to accommodate such effects into their conceptual models and examine pathways between multiple multilevel risk factors which vary over time. Such an approach would lead to an improved understanding of dimensions and pathways in oral health and to the proximate mechanisms for these effects which, in turn, would facilitate our understanding of how social inequalities 'get into the mouth'. Designing interventions which do not take into account such complex interrelationships are likely to be ineffective as seen in many oral health education programmes (Kay and Locker, 1996).

Table 2. Standardised estimates for each of the SEP measures on oral health by gender and age group.

	Indicator of SEP	Model I Direct effect	Model Model II Direct effect	Indirect effect
Gender				
Male	Education	-.014	-.014	.036**
	Occupation	.213**	.213**	.049*
	Income	-.143*	-.143*	-
Female	Education	.005	.005	.076*
	Occupation	.116	.116*	.073*
	Income	.284	.284*	-
Age				
16-41 yrs	Education	.108*	.108*	.019*
	Occupation	.163**	.163**	.090**
	Income	.284**	.284**	-
42+ yrs	Education	-.049	-.049	.058**
	Occupation	.106**	.106**	.039**
	Income	-136***	.136**	-

Note: Figures are for the unconstrained models. * p < .05, ** p < .01, *** p < .001.

CONCLUSIONS. LIMITATIONS AND CAVEATS

The analysis presented here is a simplified representation of socio-economic pathways in order to illustrate the type of analysis that is possible. As such, there are a number of limitations with the study. Firstly, the measures of SEP were very blunt. For example, only three social class and education groups were included, and these were grouped together in ways to facilitate the statistical analysis, rather than on any conceptual basis. This is largely because, as previously recognised, there are a number of difficulties using SEM on population surveys such as that modelled here (Newton & Bower, 2005). In addition, survey data is collected predominantly for description of risk factors rather than explanation of underlying mechanisms. By using such datasets, the analysis is limited in that it includes only variables that are easy to measure and quantify, ignoring those that are difficult to assess but which are equally important in understanding health. For example, here, only three indicators of SEP were included; however, SEP incorporates a number of resource- and prestige-based components which will be of importance (Krieger *et al*., 1997). Furthermore, the analysis did not incorporate other intermediates in the social inequalities-oral health pathway (e.g. oral health behaviour; perceived need; access; psychosocial resources) (Andersen, 1995). Thus, the present paper does not attempt to contribute to the debate about how social inequalities impact on oral health; that is, the behavioural, attitudinal and environmental mechanisms (Sisson, 2007). To understand socio-economic pathways it will be necessary to adopt a theoretically driven life-course approach (Newton and Bower, 2005). Whilst the data here were cross-sectional, which means that no conclusions can be drawn about cause and effect, the findings help elucidate important hypotheses for such future longitudinal life course studies.

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