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The role of socio-economic position in predicting orthodontic treatment outcome at the end of 1 year of active treatment

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SUMMARY Socio-economic position (SEP) has not been tested as a predictor of orthodontic treatment outcome. This study aimed to determine whether SEP can predict orthodontic treatment outcome at the end of 1 year of active treatment. A hospital-based, prospective longitudinal design was adopted including 145 consecutively selected 12- to 16-year-old males and females. Patients were followed-up on a monthly basis during their orthodontic treatment with fixed appliances. After 1 year of treatment, orthodontic treatment outcome was assessed as the amount of improvement in occlusion achieved. Logistic regression analysis was used.

The response rate was 98.6 per cent and the dropout was 5.6 per cent. Adolescents whose mothers were from a low social class were less likely to achieve a high improvement in occlusion than those whose mothers were from a high social class [odds ratio (OR) = 0.1; 95 per cent confidence interval (CI) = 0.01–0.97; $P = 0.047$). Adolescents from a low household social class were less likely to achieve a high improvement in occlusion compared with their counterparts from a high household social class (OR = 0.2; 95 per cent CI = 0.07–0.79; $P = 0.019$). The father's social class, parental education, and employment status were not significantly associated with improvement in occlusion ($P > 0.05$). The regression model confirmed the significance of maternal and household social class as predictors of orthodontic treatment outcome at the end of 1 year of active treatment.

Introduction

Predicting orthodontic treatment outcome is of major interest. Potentially £11.4 million is wasted annually due to orthodontic treatment failure (Shaw *et al.*, 2003). In response to these findings, a number of studies have attempted to investigate factors predicting orthodontic treatment outcome. These have focused on biological, behavioural, and health care predictors such as malocclusion severity (Fox *et al.*, 1997), adherence to treatment (Taylor *et al.*, 1996), type of appliance (O'Brien *et al.*, 1993; Teh *et al.*, 2000), and clinician's qualification (Richmond *et al.*, 1993).

A new approach in the medical literature has emerged to predict different treatments outcomes using socio-economic position (SEP). This approach highlighted socio-economic inequality in adolescent response to cancer, cystic fibrosis, asthma, conduct disorders, and obesity treatments (McWhirter *et al.*, 1983; Halfon and Newacheck, 1993; Schechter *et al.*, 2001; Langnase *et al.*, 2004; Reyno and McGrath, 2006). Adolescents of low SEP were less likely to achieve successful treatment outcomes when compared with their counterparts of high SEP. The relatively minor contradictory findings reported in the literature might be due largely to the conceptual limitation of the SEP indicators used. SEP includes two concepts: social class (ownership or control of resources) and social status (prestige or honour in the community; Liberatos *et al.*, 1988; Krieger *et al.*, 1997). Measuring these two concepts is challenging because they are not directly measurable but operationalized indirectly by a number of indicators, namely occupation, income, education, and employment status that can be collected at individual, household, and neighbourhood levels (Liberatos *et al.*, 1988). While occupation and income measure the social class domain in the SEP, education and employment status have no conceptual clarity concerning what they exactly measure within the SEP. Both of these indicators can straddle class and status domains (Liberatos *et al.*, 1988). Education, for example, on the one hand, is used as a proxy measure for variables in the class domain because it can provide qualification to acquire better occupation and income. On the other hand, it reflects the amount of knowledge that a person has acquired which can affect their lifestyle and social network (status; Jacobsen and Thelle, 1988). This might explain why studies that used occupation or income reported consistent socio-economic differences in adolescent treatment outcomes (Walters *et al.*, 1972; McWhirter *et al.*, 1983; Reyno and McGrath, 2006) while those that used education or employment status failed to

show similar consistent findings (Miller-Johnson *et al.*, 1994; Levine *et al.*, 2001; Gallegos-Macias *et al.*, 2003). Similarly, the lack of a conceptual framework underlying the development process of the UK neighbourhood level measures poses serious limitations (Locker, 1993) and may, therefore, explain the contradictory findings reported in the literature (Szklo *et al.*, 1978; Coleman *et al.*, 1999; Schillinger *et al.*, 1999). These measures were constructed from conditions or types of individuals subject to these conditions, such as unemployment and children under 5 years of age (Townsend *et al.*, 1988). No previous study has used SEP indicators measured at a household level in predicting adolescent treatment outcome. This approach is highly relevant to studies conducted on adolescents as it is family resources and standards of living and not necessarily parents' individual socio-economic characteristics that might play a major role in adolescents' health, development, and treatment outcome (Krieger *et al.*, 1997).

Despite the abovementioned evidence regarding socio-economic inequality in adolescent treatment outcomes, SEP has not been used before to predict orthodontic treatment preliminary or final outcome. This study aimed to test whether SEP can predict orthodontic treatment outcome at the end of 1 year of active treatment. It was hypothesized that adolescents who are of low SEP are less likely to achieve a successful orthodontic treatment outcome at the end of 1 year of active treatment compared with those of high SEP.

Subjects and methods

Ethical approval was obtained from the East London and City Health Authority Local Research Ethics Committee (REC: P3/04/Q0605/59) and written consent from the child and a parent/guardian.

A hospital-based, prospective longitudinal design was adopted. A minimum sample size of 126 patients distributed into two groups was proposed to demonstrate a 2.5-fold or greater odds ratio in explanatory variables. The level of significance was set at 5 per cent. Assuming a maximum 15 per cent dropout, a total of 145 patients was required.

Patients commencing orthodontic treatment between November 2004 and March 2006 and undergoing fixed appliance therapy by specialist registrars were consecutively selected from the Orthodontic Clinic, Barts and the London Hospital. The inclusion criteria were male and female patients, aged 12–16 years old, who demonstrated one or more of the following malocclusion traits according to the British Standards Institute (1983) definitions: upper anterior crowding, upper anterior spacing, increased overjet, anterior crossbite, or reverse overjet. The included malocclusion traits were suitable for correction with fixed appliances alone. The exclusion criteria were patients who had previously received orthodontic treatment, required removable or functional appliances or adjunctive orthodontic treatment, those with learning difficulties, or with systemic and/or developmental disorders.

Baseline data collection was carried out before placement of the fixed appliances. Thereafter, the patients were followed up on a monthly basis to obtain information related to their adherence to orthodontic treatment. After 1 year of active orthodontic treatment, outcome was measured as the improvement in occlusion achieved. This period of fixed appliance treatment is considered sufficient to achieve an improvement in different malocclusion traits (Profitt *et al.*, 2007) and may serve as an indicator of the amount of final improvement that could be anticipated. This is evident since orthodontic treatment takes place in progressive stages where the successful completion of one stage is a predictor, and mandatory for the initiation and success of subsequent stages (Profitt *et al.*, 2007).

The improvement in occlusion was measured using |the Index of Treatment Complexity, Outcome and Need (ICON; Daniels and Richmond, 2000). The ICON's four components: crossbite, upper arch crowding/spacing, anterior vertical relationship, and buccal segment antero-posterior relationship provide a valid tool to assess improvement in occlusion during orthodontic treatment. The improvement formula suggested by Daniels and Richmond (2000) was adopted and expressed as: [pre-treatment ICON score for four components] $-4 \times$ [1 year treatment ICON score for four components]. Orthodontic treatment outcome at the end of 1 year of active treatment was considered successful if the patient achieved a high improvement in occlusion (a score equal to or higher than the median) and unsuccessful if the patient achieved a low or no improvement in occlusion (a score lower than the median).

Explanatory variables included SEP, demographics, behavioural, and clinical variables. SEP was measured using parent/guardian(s) occupation, education, and employment status at individual and household levels. Occupation is considered an indicator of the social class domain of SEP. It was measured using the Standard Occupational Classification (SOC, 2000). In the case of an adolescent having an unemployed or retired parent/guardian(s), the SOC (2000) does not provide any classification. Thus, this information was considered missing. Education and employment status are considered indicators of social class and/or social status domains of SEP. Education was measured by the highest qualification obtained (Liberatos *et al.*, 1988). Employment status information included being employed or unemployed. If the child came from a single-parent headed family, the SEP information of the other parent was considered missing. At a household level, SEP was measured by assigning the family the SEP of the parent/guardian with the higher position (Krieger *et al.*, 1997). Demographic data included age, gender, and ethnicity. Behavioural data included patient's adherence to orthodontic treatment in terms of

attendance, punctuality, and appliance maintenance (Fox *et al.*, 1997). As adherence information was collected on a monthly basis, a summary score for each of these three adherence indicators was obtained. The percentages of attended appointments, of punctual appointments, and of appliance maintenance were calculated. A composite adherence indicator was constructed from these adherence indicator summary scores. Each summary score was dichotomized into high (score 0) and low (score 1) levels. The new scores were summed to result in a range of scores from 0 to 3. Patients with scores 0 and 1 were considered to have high levels of adherence while those with scores 2 and 3 were considered to have low levels. Information on clinical variables, namely malocclusion severity/treatment complexity, type of anterior malocclusion, type of appliance, and clinician's skills were also collected. Malocclusion severity/treatment complexity was measured as proposed by Daniels and Richmond (2000) by the pre-treatment ICON score. The cut-off points suggested by the authors were used to reflect mild, moderate, difficult, and very difficult cases.

A child self-completed questionnaire was used to collect the SEP and demographic data, while the clinicians were asked to report child adherence on a special form. The clinical data were collected from the child's hospital notes and by clinical examination.

Statistical analysis

Intra-examiner reliability was assessed and then the effect of explanatory variables on improvement in occlusion using simple logistic regression analysis. Explanatory variables that were significant at the 0.2 level (Altman, 1991) were selected to enter a regression model. This step aimed to ensure that the observed relationship between SEP indicators and improvement in occlusion would persist in the presence of demographic and known predictors of orthodontic treatment outcome. This, in turn, would confirm the significance of SEP as a predictor of orthodontic treatment outcome at the end of 1 year of active treatment.

Results

A response rate of 98.6 per cent was obtained, with a dropout of 5.6 per cent. Thus, the total number of subjects who were followed up for 1 year was 135, maintaining the power of the study. There were no missing data due to failure in collecting relevant information. Cohen's unweighted kappa coefficient for the presence of a high versus a low/no improvement in occlusion was 1, indicating perfect agreement.

Males comprised 33.3 per cent of the sample. The ICON scores of improvement in occlusion ranged from −155 to 19. The mean was −37.4 ± 30.8 (SD).

The difference in improvement in occlusion between adolescents whose mothers were from a high social class (60.3 per cent) and those whose mothers were from a low social class (14.3 per cent) was large and statistically significant (P = 0.047). Adolescents whose mothers were from a low social class were less likely to achieve a high improvement in occlusion compared with their counterparts whose mothers were from a high social class [odds ratio (OR) = 0.1; 95 per cent confidence interval (CI) = 0.01–0.97; Table 1]. The mother's social class was more relevant to improvement in occlusion than the father's social class (P = 0.047, 0.222, respectively; Table 1). With respect to household social class, the difference in improvement in occlusion between adolescents from a high (58.6 per cent) and those from a low (25 per cent) household social class was large and statistically significant (P = 0.019; Table 1). Adolescents from a low household social class were less likely to achieve a high

Table 1 Frequency of socio-economic indicators, odds ratios (OR), and 95 per cent confidence intervals (95% CIs) to predict odds of high improvement in occlusion (n = 135).

Variable	Base	Frequency of high improvement in occlusion (%)	OR (95% CI)	P-value
Father's social class				
High	58	34 (58.6)	1	
Low	25	11 (44)	0.6 (0.22–1.43)	0.222
Missing values	52			
Mother's social class				
High	58	35 (60.3)	1	
Low	7	1 (14.3)	0.1 (0.01–0.97)	0.047
Missing values	70			
Household social class				
High	87	51 (58.6)	1	
Low	16	4 (25)	0.2 (0.07–0.79)	0.019
Missing values	32			
Father's education				
High	63	34 (54)	1	
Low	48	22 (45.8)	0.7 (0.34–1.53)	0.396
Missing values	24			
Mother's education				
High	64	34 (53.1)	1	
Low	69	34 (49.3)	0.9 (0.43–1.69)	0.657
Missing values	2			
Household education				
High	82	43 (52.4)	1	
Low	53	25 (47.2)	0.8 (0.41–1.62)	0.550
Missing values	0			
Father's employment				
Employed	83	45 (54.2)	1	
Unemployed	28	11 (39.3)	0.5 (0.23–1.31)	0.275
Missing values	24			
Mother's employment				
Employed	65	36 (55.4)	1	
Unemployed	68	32 (47.1)	0.7 (0.36–1.42)	0.338
Missing values	2			
Household employment				
Employed	101	53 (52.5)	1	
Unemployed	34	15 (44.1)	0.7 (0.33–1.56)	0.400
Missing values	0			

improvement in occlusion compared with their high household social class counterparts (OR = 0.2; 95 per cent CI = 0.07–0.79; Table 1).

With respect to the father's, the mother's, and household education and employment status, the differences between groups were small and not statistically significant (Table 1).

From the demographic, behavioural, and clinical variables included in this study, ethnicity, adherence, malocclusion severity/treatment complexity, type of anterior malocclusion, and clinician skills were significant at the 0.2 level (Table 2).

Two regression models were performed to confirm the significance of the mother's and household social class. Due to the high correlation between these two variables (rho = 0.918) that would cause colinearity, they could not be added to the same model. Model 1, adjusted for ethnicity, adherence, malocclusion severity/treatment complexity, type of anterior malocclusion, and clinician's skills, confirmed the significance of the mother's social class as a predictor of improvement in occlusion (Table 3). Similarly, model 2, adjusted for ethnicity, adherence, malocclusion severity/treatment complexity, type of anterior malocclusion, and clinician's skills, confirmed the significance of household social class as a predictor of improvement in occlusion (Table 4).

Table 2 Frequency of demographic, behavioural, and clinical variables, odds ratios (OR), and 95 per cent confidence intervals (95% CIs) to predict odds of high improvement in occlusion (n = 135).

Variable	Base	Frequency of high improvement in occlusion (%)	OR (95% CI)	P-value
Age groups				
12	20	11 (55)	1	
13	37	20 (54.1)	1 (0.32–3.87)	0.945
14	39	19 (48.7)	0.8 (0.26–2.29)	0.648
15 and 16	39	18 (46.2)	0.7 (0.24–2.07)	0.521
Missing values	0			
Gender				
Male	45	20 (44.4)	1	
Female	90	48 (53.3)	1.4 (0.70–2.93)	0.331
Missing values	0			
Ethnicity				
White	45	27 (60)	1	
Mixed	8	7 (87.5)	4.7 (0.53–41.2)	0.166
Asian	56	25 (44.6)	0.5 (0.24–1.19)	0.126
Black	26	9 (34.6)	0.4 (0.13–0.96)	0.042
Missing values	0			
Adherence indicator				
High	84	50 (73.5)	1	
Low	51	18 (35.3)	0.4 (0.18–0.76)	0.007
Missing values	0			
Malocclusion severity/treatment complexity				
Very difficult	70	37 (52.9)	1	
Difficult	43	17 (39.5)	0.6 (0.27–1.26)	0.170
Moderate	14	8 (57.1)	1.2 (0.37–3.79)	0.769
Mild	8	6 (75)	2.7 (0.51–14.2)	0.247
Missing values	0			
Type of anterior malocclusion				
Two or three types	102	56 (54.9)	1	
Increased overjet	14	4 (28.6)	0.3 (0.10–1.12)	0.075
Anterior crossbite	13	7 (53.8)	1 (0.30–3.05)	0.943
Anterior crowding	6	1 (16.7)	0.2 (0.02–1.46)	0.105
Missing values	0			
Type of appliance				
One-arch	12	6 (50)	1	
Two-arch	123	62 (50.4)	1 (0.31–3.33)	0.979
Missing values	0			
Clinician's skills				
Poor	37	12 (32.4)	1	
Moderate	39	17 (43.6)	1.6 (0.63–4.10)	0.318
High	31	18 (58.1)	2.9 (1.07–7.77)	0.036
Very high	28	21 (75)	6.3 (2.09–18.7)	0.001
Missing values	0			

Discussion

The current findings support the hypothesis that adolescents of low SEP are less likely to achieve a successful orthodontic treatment outcome at the end of 1 year of active treatment compared with those of high SEP. Indeed, this finding adds to the existing body of evidence highlighting socio-economic inequality in adolescent response to different treatments (McWhirter *et al.*, 1983; Halfon and Newacheck, 1993; Schechter *et al.*, 2001; Langnase *et al.*, 2004; Reyno and McGrath, 2006).

The observed SEP differences in improvement in occlusion depended on the SEP indicator used. The current study replicated the findings of other investigations showing that, among the adopted indicators, only occupation detected SEP differences in adolescent orthodontic treatment outcome at the end of 1 year of active treatment. This might be largely due to the aforementioned conceptual limitations of education and employment status.

The significance of the mother's rather than the father's social class was also interesting. As mothers assume and take more responsibility for adolescent treatment (Bregani *et al.*, 1978), it seems that the characteristics of the mother's employment play a major role in determining the extent to which they are able to provide support in their child's treatment. For example, mothers from a low social class, who are expected to have less job control and more stressful working conditions, may be less able to take time off work and accompany their child on his/her orthodontic treatment visits.

Another interesting finding related to the differences between individual and household levels of SEP indicators. As family resources and standards of living might play a major role in adolescent health, development, and treatment outcome (Krieger *et al.*, 1997), it was not surprising to find that household social class was more significant than parents' individual social class. In the current study, household social class was measured by the 'dominance' approach rather than the 'cross-class' approach. The latter involves classifying the household by the actual SEP and gender composition of the heads-of-household (Sorensen, 1994). However, the problems arising from selecting a valid

Table 3 Frequency distribution, unadjusted odds ratios (OR), adjusted OR, and 95 per cent confidence intervals (95% CIs) to predict odds of high improvement in occlusion; Model 1 (n = 135).

Variable	Base	Frequency of high improvement in occlusion (%)	Unadjusted OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Mother's social class						
High	58	35 (60.3)	1		1	
Low	7	1 (14.3)	0.1 (0.01–0.97)	0.047	0.1 (0.01–0.56)	0.025
Ethnicity						
White	45	27 (60)	1		1	
Mixed	8	7 (87.5)	4.7 (0.53–41.2)	0.166	4.6 (0.14–154.09)	0.391
Asian	56	25 (44.6)	0.5 (0.24–1.19)	0.126	0.1 (0.01–0.81)	0.036
Black	26	9 (34.6)	0.4 (0.13–0.96)	0.042	0.6 (0.07–4.41)	0.591
Adherence indicator						
High	84	50 (73.5)	1		1	
Low	51	18 (35.3)	0.4 (0.18–0.76)	0.007	0.7 (0.11–4.98)	0.746
Malocclusion severity/treatment complexity						
Very difficult	70	37 (52.9)	1		1	
Difficult	43	17 (39.5)	0.6 (0.27–1.26)	0.170	0.9 (0.17–5.61)	0.971
Moderate	14	8 (57.1)	1.2 (0.37–3.79)	0.769	133.4 (0.01–1900687)	0.316
Mild	8	6 (75)	2.7 (0.51–14.2)	0.247	35.7 (0.11–11501.12)	0.225
Type of anterior malocclusion						
Two or three types	102	56 (54.9)	1		1	
Increased overjet	14	4 (28.6)	0.3 (0.10–1.12)	0.075	0.1 (0.01–6.05)	0.310
Anterior crossbite	13	7 (53.8)	1 (0.30–3.05)	0.943	0.1 (0.01–0.83)	0.042
Anterior crowding	6	1 (16.7)	0.2 (0.02–1.46)	0.105	0.1 (0.01–0.5.0E+27)	0.825
Clinician's skill						
Poor	37	12 (32.4)	1		1	
Moderate	39	17 (43.6)	1.6 (0.63–4.10)	0.318	2.7 (0.44–16.91)	0.284
High	31	18 (58.1)	2.9 (1.07–7.77)	0.036	17.3 (1.27–237.47)	0.033
Very high	28	21 (75)	6.3 (2.09–18.7)	0.001	107.6 (3.48–3325.38)	0.008

Table 4 Frequency distribution, unadjusted odds ratios (OR), adjusted OR, and 95 per cent confidence intervals (95% CIs) to predict odds of high improvement in occlusion; Model 2 (n = 135).

Variable	Base	Frequency of high improvement in occlusion (%)	Unadjusted OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Household social class						
High	87	51 (58.6)	1		1	
Low	16	4 (25)	0.2 (0.07–0.79)	0.019	0.1 (0.02–0.60)	0.012
Ethnicity						
White	45	27 (60)	1		1	
Mixed	8	7 (87.5)	4.7 (0.53–41.2)	0.166	2 (0.26–15.42)	0.501
Asian	56	25 (44.6)	0.5 (0.24–1.19)	0.126	0.2 (0.06–0.76)	0.017
Black	26	9 (34.6)	0.4 (0.13–0.96)	0.042	0.6 (0.12–2.51)	0.446
Adherence indicator						
High	84	50 (73.5)	1		1	
Low	51	18 (35.3)	0.4 (0.18–0.76)	0.007	0.5 (0.16–1.57)	0.236
Malocclusion severity/treatment complexity						
Very difficult	70	37 (52.9)	1		1	
Difficult	43	17 (39.5)	0.6 (0.27–1.26)	0.170	0.1 (0.21–2.16)	0.501
Moderate	14	8 (57.1)	1.2 (0.37–3.79)	0.769	7.8 (1.03–59.43)	0.046
Mild	8	6 (75)	2.7 (0.51–14.2)	0.247	7.8 (0.44–140.33)	0.163
Type of anterior malocclusion						
Two or three types	102	56 (54.9)	1		1	
Increased overjet	14	4 (28.6)	0.3 (0.10–1.12)	0.075	0.3 (0.04–2.55)	0.279
Anterior crossbite	13	7 (53.8)	1 (0.30–3.05)	0.943	0.1 (0.01–0.73)	0.025
Anterior crowding	6	1 (16.7)	0.2 (0.02–1.46)	0.105	0.2 (0.01–3.11)	0.244
Clinician's skills						
Poor	37	12 (32.4)	1		1	
Moderate	39	17 (43.6)	1.6 (0.63–4.10)	0.318	2.3 (0.63–8.54)	0.205
High	31	18 (58.1)	2.9 (1.07–7.77)	0.036	6 (1.40–25.67)	0.016
Very high	28	21 (75)	6.3 (2.09–18.7)	0.001	10.5 (2.01–55.11)	0.005

and updated method for assigning weights to heads-of-household poses limitations (Krieger *et al.*, 1997). The dominance approach, adopted in this study, is proposed to be more accurate in view of the tendency towards upward mobility (Haug, 1973). It is more likely that a family will function at the higher position level. In other words, a female with a lower occupational level does not lower the social class of the male but a female with a higher occupational level raises the family's social class. However, others have questioned the validity of this approach in the light of the different economic returns for occupation and education between males and females (Bose and Rossi, 1983). This may no longer be an issue in view of recent gender occupational and income equality being applied.

The prospective and longitudinal design of the current study elucidated a temporal relationship between SEP and orthodontic treatment outcome at the end of 1 year of active treatment. Yet, drawing a causal relationship is not possible due to the observational nature of this study. In addition, although improvement in occlusion achieved in 1 year may serve as an indicator of the amount of final improvement, more profound evidence may be drawn from assessing improvement at the end of treatment.

Finally, the clinical inability of using the ICON's aesthetic component due to the presence of fixed appliance *in situ* did not affect the overall validity of the ICON in measuring the corresponding aspects of improvement in occlusion by its other four components. Since each of the components is assigned a weighting score that was driven from its regression coefficient, assigning the aesthetic component as a constant of zero in the equation does not change the regression coefficients of the other four components (Altman, 1991). This, in turn, does not change the weighting system to drive a mathematical final score for these four components and reflect the amount of improvement achieved.

Conclusions

The current study provides evidence of the importance of the mother's and household social class as a means to identify adolescents who may be at risk of poor orthodontic treatment outcome. These adolescents may need special interventions to enhance their chances of achieving a successful result.

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