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Social influences on health-related behaviour clustering during adulthood in two British birth cohort studies

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ABSTRACT

Building upon evidence linking socio-economic position (SEP) in childhood and adulthood with health-related behaviours (HRB) in adulthood, we examined how pre-adolescent SEP predicted membership of three HRB clusters: "Risky", "Moderate Smokers" and "Mainstream" (the latter pattern consisting of more beneficial HRBs), that were detected in our previous work.

Data were taken from two British cohorts (born in 1958 and 1970) in pre-adolescence (age 11 and 10, respectively) and adulthood (age 33 and 34). SEP constructs in pre-adolescence and adulthood were derived through Confirmatory Factor Analysis. Conceptualised paths from pre-adolescent SEP to HRB cluster membership via adult SEP in our path models were tested for statistical significance separately by gender and cohort.

Adult SEP mediated the path between pre-adolescent SEP and adult HRB clusters. More disadvantaged SEP in pre-adolescence predicted more disadvantaged SEP in adulthood which was associated with membership of the "Risky" and "Moderate Smokers" clusters compared to the "Mainstream" cluster. For example, large positive indirect effects between pre-adolescent SEP and adult HRB via adult SEP were present (coefficient 1958 Women = 0.39; 1970 Women = 0.36, 1958 Men = 0.51; 1970 Men = 0.39; $p < 0.01$) when comparing "Risky" and "Mainstream" cluster membership. Amongst men we found a small significant direct association ($p < 0.001$) between pre-adolescent SEP and HRB cluster membership.

Our findings suggest that associations between adult SEP and HRBs are not likely to be pre-determined by earlier social circumstances, providing optimism for interventions relevant to reducing social gradients in HRBs. Observing consistent findings across the cohorts implies the social patterning of adult lifestyles may persist across time.

1. Introduction

Research evidence indicates that four health-related behaviours (HRBs), smoking, alcohol, diet and physical activity, cluster together and that HRB clustering is socially patterned (Noble et al., 2015; Meader et al., 2016). More disadvantaged social circumstances in adulthood, captured through socio-economic position (SEP), are associated with membership of clusters characterised by multiple negative HRBs (i.e. smoking, heavy alcohol consumption, physical inactivity, low fruit and vegetable consumption).

Evidence from cohort studies using prospectively collected data suggest that more disadvantaged childhood SEP is associated with negative HRBs in adulthood (Clouston et al., 2015; Lacey et al., 2010; Bann et al., 2016). Studies testing for mediation have found both a direct effect of childhood SEP on adult HRBs and an indirect effect via adult SEP (van de Mheen et al., 1998; Kamphuis et al., 2013; Elhakeem et al., 2015; Watt et al., 2009; Pudrovska and Anishkin, 2013; Schooling and Kuh, 2002; Yang et al., 2008). Other studies have found direct effects of childhood SEP on adult HRBs are fully explained by adult SEP (Kvaavik et al., 2012; Kestila et al., 2015; Paavola et al., 2004). However, some of these mediation studies relied on retrospective accounts of social circumstances in childhood (Elhakeem et al., 2015; Watt et al., 2009; Kestila et al., 2015) or used single measures of SEP (van de Mheen et al., 1998; Kamphuis et al., 2013; Elhakeem et al., 2015; Kvaavik et al., 2012). Notably, none of these studies consider HRB clustering.

To date only one study has considered how SEP early in life shapes HRB clustering in adulthood (Falkstedt et al., 2016). This study found

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disadvantaged SEP in childhood and adulthood was predictive of membership in clusters characterised by multiple negative HRBs. Whilst insightful, this study included parental education as the only measure of SEP which limits it's impact given that SEP is arguably multi-faceted (Bartley, 2016), influencing HRBs through factors such as economic circumstances, social norms and employment relations (Sacker et al., 2001). Moreover, in this study parental education was based on retrospective accounts from participants (Falkstedt et al., 2016), which may be subject to recall bias (Cohen et al., 2010), potentially underestimating the effects of childhood SEP on adult HRB clustering, given the better measurement of adult SEP.

To address these limitations, we built upon our previous work (Mawditt et al., 2016), to investigate the influence of SEP in pre-adolescence and adulthood on membership of three distinct clustered patterns of adult HRBs: "Risky", "Moderate Smokers" and "Mainstream", in two British cohorts born in 1958 (the National Child Development Study, NCDS, (Power and Elliott, 2006)) and 1970 (the British Birth Cohort Study, BCS70, (Elliott and Shepherd, 2006)). The NCDS and the BCS70, purposefully mirror each other in design to include rich and similar measures of HRBs during mid-life and social circumstances across the lifecourse (Ekinsmyth et al., 1992). Information on SEP in childhood was prospectively collected, rather than retrospectively, thus minimising recall bias (Cohen et al., 2010).

We focused on pre-adolescent SEP (adapting the definition of pre-adolescence as age 8 to 11, (Maggs et al., 2008)) as opposed to adolescent and young adult SEP, given that the latter ages are normative periods of HRB experimentation (Schooling and Kuh, 2002; Fothergill et al., 2009), increasingly influenced by external factors such as peer groups and popular media rather than household SEP (Vallejo-Torres et al., 2014; West, 1997; Weyers et al., 2010). Moreover, compared to younger children, pre-adolescent children are more conscious of their identity and differences in social background (West et al., 2010; Leahy, 1981).

It is conceived possible that SEP experienced during pre-adolescence may directly influence HRBs in adulthood by embedding some HRBs through regular participation and establishing attitudes and beliefs towards other HRBs they are yet to experience. It is also conceived possible that pre-adolescent SEP will set children on lifelong SEP trajectories, shaping their SEP in adulthood and subsequently influence HRB cluster membership at the same age.

We hypothesise as follows:

1) More disadvantaged pre-adolescent SEP will predict membership of adult HRB clusters characterised by multiple negative HRBs.
2) Adult SEP will mediate the relationship between pre-adolescent SEP and adult HRB cluster membership.

2. Methods

2.1. Sample

Data were taken from both the National Child Development Study (NCDS) (Power and Elliott, 2006) and the British Birth Cohort Study (BCS70) (Elliott and Shepherd, 2006). The analytical sample was 11,373 in the NCDS (men = 5586, women = 5787) and 9646 in the BCS70 (men = 4613, women = 5033). All of the participants had information on at least one HRB from adulthood and one SEP indicator from either pre-adolescence or adulthood.

Where possible information on adult HRBs and SEP was taken at age 33 in the NCDS (CLS, 2008a) and age 34 in the BCS70 (CLS, 2016a) and indicators of SEP in pre-adolescence were primarily taken at age 11 in the NCDS (CLS, 2014) and age 10 in the BCS70 (CLS, 2016b).

However, some information was taken at age 7 (CLS, 2014) and age 42 (CLS, 2008b) in the NCDS and age 5 (Butler et al., 2016) and age 30 (CLS, 2016c) in the BCS70 (see Appendix A) when questionnaire items were not asked at our main ages of interest. We consider it reasonable to assume that responses to these indicators were very similar during the relatively short periods between the ages of data collection and the ages of interest (e.g. parental education at age 7 instead of age 11).

The data were ethically collected and anonymised. Pre-2000 studies were subject to internal ethical review and post-2000 studies were approved by an external research ethics committee (Shepherd, 2012a; Shepherd, 2012b).

2.2. Measures

2.2.1. Outcome: HRB cluster membership

The outcome in the analysis was based upon a latent categorical variable derived separately by cohort and gender in our previous work (Mawditt et al., 2016). This variable measures the clustered patterns and prevalence of four HRBs: smoking, alcohol, diet and physical activity, and consists of three HRB clusters: "Risky", "Moderate Smokers" and "Mainstream".

The "Mainstream" cluster (68–77%) represents the most prevalent HRB patterns in the two cohorts and is characterised by more health-promoting behavioural patterns, i.e. not smoking, frequent fruit and vegetable consumption, less frequent consumption of chips and fried food, being more physically active, although frequent consumption of sweet foods tends to be more common in this cluster compared to the others. The "Risky" cluster (1–9%) is the smallest cluster and is largely characterised by multiple negative HRBs (i.e. heavy smoking, more frequent consumption of chips and fried food, lower levels of physical activity). The "Moderate Smokers" cluster (20–30%) is a mixture of both positive and negative HRBs, smoking behaviour notably distinguishes this cluster from the others although levels of smoking are lower than the "Risky" cluster.

In this analysis the outcome, originally derived as latent, was treated as observed and operationalised by "modally assigning" participants to their most likely HRB cluster (Heron et al., 2015). This approach aids model convergence and retains the nature of the original latent variable when incorporating covariates (Heron et al., 2015; Vermunt, 2010) and is considered reasonable when classification error is low i.e. entropy > 0.8 (Clark and Muthén, 2009), as was the case in the original measurement models (Mawditt et al., 2016).

2.2.2. Pre-adolescent and adult SEP

We conceptualise SEP as multi-faceted (Bartley, 2016), influencing HRBs through factors such as economic circumstances, social norms and employment relations (Sacker et al., 2001). SEP was captured through Confirmatory Factor Analysis. Detailed information for each pre-adolescent and adult SEP measure are described in Appendix A. More information on the derivation of the SEP variables can be found in Appendix B.

2.2.3. Pre-adolescent SEP

We captured SEP in the context of economic and cultural norms. Indicators selected to capture pre-adolescent household economic circumstance are living in social housing, overcrowding, receiving free school meals, in receipt of benefits associated with disadvantage and income (BCS70 only), whilst indicators of cultural norms are parental education and their interest in the child's education. In our study, pre-adolescent SEP is treated as an exogenous variable.

2.2.4. Adult SEP

Similar to pre-adolescent SEP, economic aspects of adult SEP are captured through receiving benefits associated with disadvantage, living in social housing, owning a car, overcrowding and household equivalised income (Anyaegbu, 2010). Cultural norms are captured by cohort participants' highest qualification achieved by age 33/34, their Cambridge scale (Prandy and Lambert, 2003), occupation class indicated by NS-SEC (ONS, 2010), and employee's benefits such as pension, medical scheme, and company shares.

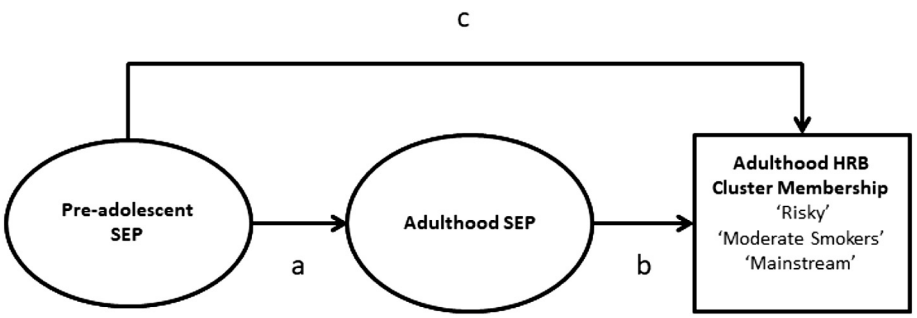

Fig. 1. The path model estimating the total effect, indirect and direct paths between pre-adolescent SEP and adult HRB cluster membership in the NCDS and BCS70. Path a × b = indirect path between pre-adolescent SEP and adulthood HRB cluster membership. Path c = direct path between pre-adolescent SEP and HRB cluster membership. Path ab + path c = total effect of pre-adolescent SEP on HRB cluster membership. Ovals represent the latent variables. Rectangles represent the observed variables.

2.3. Statistical analysis

Conceptualised paths were tested using a path model, a structural equation modelling approach (Hoyle, 2012), shown in Fig. 1. The path model estimated the *direct path* between SEP in pre-adolescence and HRB clustering in adulthood (=path c), the *indirect path* between SEP in pre-adolescence and HRB clustering in adulthood via adult SEP (=path a × b) and the total effect of pre-adolescent SEP on HRB clustering which is equal to the sum of the *indirect* and *direct* paths (=path ab + path c).

Probit regressions were used to estimate the magnitude of the relationship between the outcome, exogenous and mediator variables (Muthén and Muthén, 2012). Bias-corrected bootstrapped confidence intervals that account for asymmetry, were estimated for the indirect relationship, based on 10,000 iterations (Hayes, 2013). All models were run separately according to cohort and gender in Mplus version 7 (Muthen, 2014) using Weighted Least Squares (WLS) with robust standard errors (MV) (Wang and Wang, 2012). Missing data for the SEP indicator variables was handled through pairwise deletion using the WLSMV estimator function (Muthén and Muthén, 2012), which assumes that missing values can be explained by pairs of variables in the model. This assumption was found to be valid in a sensitivity analysis comparing estimates from models with and without the inclusion of additional covariates known to predict missingness (results not shown).

Two binary HRB variables were created, taking the "Mainstream" cluster as the reference group due to software limitations preventing the estimation of the indirect path using nominal outcomes. 'Modally assigning' (Heron et al., 2015) HRB cluster membership does not account for classification error, potentially under-estimating standard errors of regression coefficients (Heron et al., 2015; Clark and Muthén, 2009). Therefore, a more stringent alpha threshold was used ($p < 0.01$) to determine statistical significance (Clark and Muthén, 2009).

3. Results

The socio-demographic descriptive tables are presented in Appendix C.

Tables 1 and 2 present the standardised probit regression coefficients for the total effect, indirect and direct paths between pre-adolescent SEP and adult HRB cluster membership of either "Risky" or "Moderate Smokers" comparative to "Mainstream".

3.1. The total effect of pre-adolescent SEP on HRB cluster membership in adulthood

Tables 1 and 2 show that in all subgroups the total effect was significant ($p < 0.001$), suggesting that a one-unit increase in pre-adolescent SEP (=more disadvantaged) increased the probability of membership of the "Risky" (NCDS Women = 0.52; BCS70 Women = 0.44; NCDS Men = 0.25; BCS70 Men = 0.41) or "Moderate Smokers" (NCDS Women = 0.27; BCS70 Women = 0.27; NCDS Men = 0.21; BCS70 Men = 0.21) cluster compared to the "Mainstream" cluster.

3.2. The indirect path between pre-adolescent SEP and HRB cluster membership in adulthood

In all models, a positive indirect path was identified when comparing "Risky" (coefficient NCDS Women = 0.39; BCS70 Women = 0.36, NCDS Men = 0.51; BCS70 Men = 0.39; $p < 0.01$) or "Moderate Smokers" (coefficient NCDS Women = 0.25; BCS70 Women = 0.28, NCDS Men = 0.40; BCS70 Men = 0.37; $p < 0.01$) and "Mainstream" cluster membership, suggesting the mediating effect of adult SEP largely explained the relationship between pre-adolescent SEP and HRB cluster membership.

More disadvantaged circumstances in pre-adolescence predicted more disadvantaged circumstances in adulthood (coefficient NCDS Women = 0.75; BCS70 Women = 0.63, NCDS Men = 0.73; BCS70 Men = 0.66; $p < 0.001$). In turn, more disadvantaged circumstances in adulthood increased the probability of membership of the "Risky" (coefficient NCDS Women = 0.53; BCS70 Women = 0.58, NCDS Men = 0.71; BCS70 Men = 0.58; $p < 0.001$) or "Moderate Smokers" (coefficient NCDS Women = 0.33; BCS70 Women = 0.44, NCDS Men = 0.55; BCS70 Men = 0.56; $p < 0.001$) clusters when compared to the "Mainstream" cluster.

3.3. The direct path between pre-adolescent SEP and HRB cluster membership in adulthood

Table 1 shows that for women in both cohorts the direct path between pre-adolescent SEP and cluster membership was non-significant (coefficient NCDS Women = 0.13; BCS70 Women = 0.07; $p > 0.01$) when comparing "Risky" and "Mainstream" cluster membership, which did not support our hypothesis. The same non-significant independent relationship was found amongst women in the NCDS and the BCS70 (coefficient NCDS Women = 0.02; BCS70 Women = 0.01; $p > 0.01$) when comparing "Moderate Smokers" and "Mainstream" cluster membership (see Table 2).

This non-significant direct path between pre-adolescent SEP and adult HRB cluster membership amongst women in the NCDS and the BCS70, suggests a mediating effect of adult SEP and that more disadvantaged social circumstances in pre-adolescence does not independently predict membership of the "Risky" and "Moderate Smokers" clusters in comparison with the "Mainstream" cluster in adulthood.

For BCS70 Men, a non-significant direct path (coefficient 0.03, $p > 0.01$) was found when comparing "Risky" and "Mainstream" cluster membership (see Table 1), indicating a large mediating effect of adult SEP whereas for NCDS Men the association was negative, but not significant (coefficient − 0.27, $p = 0.01$). For men in both cohorts there was a significant direct path (coefficient NCDS Men = −0.19; BCS70 Men = −0.16; $p < 0.001$) between pre-adolescent SEP and "Moderate Smokers" compared to "Mainstream" cluster membership (see Table 2). Despite being statistically significant the direct effect sizes were small indicating that adult SEP largely mediates the association between pre-adolescent SEP and HRB cluster membership.

The direct path was found to be negative, rather than positive,

Table 1
Probit regression coefficients for the total effect, indirect and direct paths between pre-adolescent SEP and HRB cluster membership ("Risky" vs "Mainstream"). Data: two British birth cohort studies, the National Child Development Study (NCDS) at age 0 (1958), 7 (1965), 11 (1969), 33 (1991) and 42 (2000), the British Cohort Study (BCS70) at age 5 (1985), 10 (1980), 30 (2000) and 34 (2004).

Subgroup	Total effect (path c + path ab)	Indirect path from pre-adolescent SEP to adult HRB (path ab)	Direct path from pre-adolescent SEP to adult HRB (path c)	Pre-adolescent SEP to adult SEP (path a)	Adult SEP to adult HRB (path b)	CFI; RMSEA
NCDS Women (n = 5787)	0.52 (0.48, 0.57)**	0.39 (0.33, 0.46)**	0.13 (0.04, 0.22)	0.75 (0.73, 0.77)**	0.53 (0.45, 0.61)**	0.942; 0.048
BCS70 Women (n = 5033)	0.44 (0.37, 0.50)**	0.36 (0.31, 0.42)**	0.07 (−0.03, 0.17)	0.63 (0.60, 0.65)**	0.58 (0.50, 0.67)**	0.939; 0.049
NCDS Men (n = 5586)	0.25 (0.16, 0.34)**	0.51 (0.41, 0.62)**	−0.27 (−0.44, −0.09)*	0.73 (0.71, 0.75)**	0.71 (0.56, 0.86)**	0.935; 0.048
BCS70 Men (n = 4613)	0.41 (0.33, 0.50)**	0.39 (0.30, 0.47)**	0.03 (−0.10, 0.16)	0.66 (0.64, 0.69)**	0.58 (0.46, 0.70)**	0.932; 0.050

Note: "Risky" coded 1, "Mainstream" cluster membership coded 0. One unit increase in pre-adolescent and adult SEP = more disadvantaged. Estimates are standardised probit regression coefficients and bias-corrected bootstrap 95% CIs (10,000 iterations), p value ≤ 0.01*, p value ≤ 0.001**. Paths a, b and c are described in Fig. 1.

amongst men. This indicates 'inconsistent mediation' (MacKinnon et al., 2000; McFatter, 1979), which may be due to pre-adolescent SEP strengthening the association between adult SEP and HRB cluster membership, as shown in Appendix D.

4. Discussion

For men and women in two British birth cohorts we found support for an indirect path between pre-adolescent SEP and adult HRB cluster membership. More disadvantaged pre-adolescence SEP strongly predicted more disadvantaged adult SEP which was, in turn, strongly associated with "Risky" and "Moderate Smokers" cluster membership in comparison to "Mainstream" cluster membership, the latter cluster consisting of more beneficial health behavioural patterns (Mawditt et al., 2016).

For men and women in both cohorts, adult SEP largely explained the relationship between pre-adolescent SEP and HRB cluster membership and direct effect sizes were non-significant amongst women ($p > 0.01$). A small significant negative direct association ($p < 0.001$) between pre-adolescent SEP and HRB cluster membership was found for men, likely due to the strengthening effect of pre-adolescent SEP on the relationship between adult SEP and HRB cluster membership. Consequently, these results offer no evidence for direct associations between pre-adolescent SEP and adult HRBs (Kvaavik et al., 2012; Kestila et al., 2015; Paavola et al., 2004).

Our results strengthen existing research findings on the continuity of social disadvantage from childhood to adulthood (Kamphuis et al., 2013; Pudrovska and Anishkin, 2013; Yang et al., 2008; Paavola et al., 2004) and that HRB clustering is socially patterned in adulthood (Noble et al., 2015; Meader et al., 2016).

The pattern of associations offers support for the 'chain of risk' (Ben-Shlomo and Kuh, 2002: 287) model in regard to lifecourse risk accumulation. This chain implies that disadvantaged social circumstances persist from childhood into adulthood and subsequently dictate the proximal environment in which people live their lives which in turn strongly influences their HRBs (Short and Mollborn, 2015). These associations also contradict the individualist paradigm which portrays adult lifestyle as an individual choice, and lend support to HRB theories that suggest an inter-play between social structure and individual agency (Cockerham, 2005). Our findings suggest factors promoting upward social mobility could contribute to adopting a healthier lifestyle in adulthood, this is an important area of future research.

Capturing multiple aspects of SEP, we found strong proximal associations between adult SEP and membership of the "Risky" and "Moderate Smokers" clusters, characterised by lower levels of physical activity and consumption of fruit and vegetables compared to the "Mainstream" cluster. These associations could be due to differentials in purchasing power dictating the ability to buy fresh fruit and vegetables (Jones et al., 2014; Pechey et al., 2013; Kelly et al., 2016) and participate in leisure time physical activity (Kelly et al., 2016; Beenackers et al., 2012; Parry, 2013; Chinn et al., 1999). Similarly, membership of the "Risky" and "Moderate Smokers" clusters implies smoking and heavier alcohol consumption which could occur through psychosocial stress triggered by exposure to material hardship (Lindström et al., 2013; Pampel et al., 2010; Hoek and Smith, 2016; Twyman et al., 2016) or job strain (Heikkilä et al., 2012; Lallukka et al., 2008; Brunner et al., 2007; Kivimäki et al., 2013; Nyberg et al., 2015). Moreover, lifestyles are likely to be shaped through frequent interactions with others who are in similar social circumstances, making these HRBs socially normative (Bann et al., 2016; Bartley, 2016).

Table 2
Probit regression coefficients for the total effect, indirect and direct paths between pre-adolescent SEP and HRB cluster membership ("Moderate Smokers" vs "Mainstream"). Data: two British birth cohort studies, the National Child Development Study (NCDS) at age 0 (1958), 7 (1965), 11 (1969), 33 (1991) and 42 (2000), the British Cohort Study (BCS70) at age 5 (1985), 10 (1980), 30 (2000) and 34 (2004).

Subgroup	Total effect (path c + path ab)	Indirect path from pre-adolescent SEP to adult HRB (path ab)	Direct path from pre-adolescent SEP to adult HRB (path c)	Pre-adolescent SEP to adult SEP (path a)	Adult SEP to adult HRB (path b)	CFI; RMSEA
NCDS Women (n = 5787)	0.27 (0.23, 0.30)**	0.25 (0.19, 0.30)**	0.02 (−0.06, 0.10)	0.75 (0.73, 0.77)**	0.33 (0.26, 0.40)**	0.941; 0.048
BCS70 Women (n = 5033)	0.27 (0.23, 0.31)**	0.28 (0.24, 0.32)**	−0.01 (−0.07, 0.05)	0.63 (0.60, 0.65)**	0.44 (0.39, 0.50)**	0.938; 0.050
NCDS Men (n = 5586)	0.21 (0.18, 0.25)**	0.40 (0.35, 0.45)**	−0.19 (−0.26, −0.12)**	0.73 (0.71, 0.75)**	0.55 (0.49, 0.61)**	0.934; 0.049
BCS70 Men (n = 4613)	0.21 (0.17, 0.25)**	0.37 (0.33, 0.41)**	−0.16 (−0.23, −0.10)**	0.66 (0.64, 0.69)**	0.56 (0.50, 0.62)**	0.931; 0.051

Note: "Moderate Smokers" coded 1, "Mainstream" cluster membership coded 0. One unit increase in pre-adolescent and adult SEP = more disadvantaged. Estimates are standardised probit regression coefficients and bias-corrected bootstrap 95% CIs (10,000 iterations), p value ≤ 0.01*, p value ≤ 0.001**. Paths a, b and c are described in Fig. 1.

4.1. Strengths and limitations

The prospective longitudinal data minimised recall bias (Cohen et al., 2010) and ensured temporality between pre-adolescent SEP and HRB clustering. The large sample size provided statistical power to conduct the analysis separately according to cohort and gender.

We used CFA to derive SEP constructs at two points in the lifecourse resulting in well-defined latent variables that were free from measurement error inherent in each SEP indicator (Hagger-Johnson et al., 2011). Moreover, incorporating these latent variables into path models is a more powerful tool in comparison to simple regression analysis (Hayes, 2013), allowing all conceptualised relationships between the SEP constructs and adult HRB cluster membership of be estimated simultaneously. Replicating the analyses in two cohorts purposefully similar in design (Ekinsmyth et al., 1992) enabled a meaningful comparison of research findings.

Further analysis found that amongst men, pre-adolescent SEP may strengthen (MacKinnon et al., 2000; McFatter, 1979; Sharpe and Roberts, 1997) the association between adult SEP and HRB cluster membership, implying a non-linear joint effect (Kline, 2011) between pre-adolescent and adult SEP on HRB cluster membership amongst men. Scholars argue that joint effects of childhood and adult SEP on behavioural outcomes are often missed because SEP measures are crude and unable to capture these complex processes (Singhammer and Mittelmark, 2010). Therefore, the detection of non-linear joint effects has been made possible here using well-defined latent variables.

Attempting to disentangle and interpret the negative direct path in isolation of the indirect path amongst men is not appropriate, given the likely existence of an exposure-mediator interaction (Howe et al., 2016). Employing more advanced statistical techniques such as four-way decomposition analysis (Howe et al., 2016) which can test for interaction and mediation simultaneously, would be a useful next step in order to disentangle direct and indirect paths, as well as the interaction between them, in these path models.

The outcome variable was treated as observed in our analysis. Participants were 'modally assigned' (Heron et al., 2015) to their most likely HRB cluster, based on a measurement model from our previous work (Mawditt et al., 2016). This approach does not consider classification error and can lead to an under-estimation of standard errors in regression models (Clark and Muthén, 2009). Therefore, we applied a more stringent alpha threshold ($p < 0.01$) to determine statistical significance (Clark and Muthén, 2009). Classification error was considered minimal due to the entropy index for the original measurement models (Mawditt et al., 2016) being above the 0.8 cut-off point suggested as indicating low classification error (Clark and Muthén, 2009). A sensitivity analysis, comparing estimates from multinomial logistic regression models that adjusted for HRB cluster classification error alongside estimates from models that did not adjust for classification error demonstrated little change to the logit coefficients (see Appendix E). This suggests that modal assignment of participants to their most likely HRB cluster did not substantially alter the results.

4.2. Policy implications

Consist findings across the two cohorts in the relationship between adult HRB cluster membership and adult social circumstances imply proximal social patterning of adult lifestyles may persist across time.

The link between pre-adolescent and adult SEP highlights the need for policies and interventions that mitigate differentials in the accumulation of resources between childhood and adulthood (Cohen et al., 2010) and thus 'give every child the best start in life' (Marmot and Bell, 2010: 15).

At the same time, the proximal influence of social circumstances on HRB cluster membership provides optimism for policymakers seeking to change adult HRBs. The findings imply that adult lifestyles are not pre-determined by earlier social circumstances and they may be modified by addressing the link between SEP and HRB in adulthood.

Breaking the link between SEP and adult HRBs requires 'upstream' policies and interventions that address the social structure experienced in adulthood (Short and Mollborn, 2015). Upstream policies and interventions move away from the individualist paradigm, by avoiding blame at the individual level and acknowledge the unequal distribution of resources that shape adult lifestyles (Maller, 2015; Katikireddi et al., 2013; Benach et al., 2013).

For example, workplaces that guarantee decent employment conditions and fair wages to workers and welfare provisions that ensure adequate income to meet basic needs are recommended (Marmot and Bell, 2010), reducing sources of occupational and economic psychosocial stress. Taxation and subsidies could be implemented (Afshin et al., 2017). Revenue incurred through taxation on foods high in sugar and fat could be used to subsidise other products such as fresh fruit and vegetables (Cobiac et al., 2017) and provide local and low cost opportunities for physical activity (Burton et al., 2012).

These upstream policies must coincide with changes in social norms (Hargreaves et al., 2010; Blue et al., 2014), which may be enacted through public health campaigns (Garrett et al., 2015; Reid et al., 2010). However, campaign efficacy depends on sustained activity and the ability to effectively target all social groups (Holmes et al., 2016). Consideration to the social circumstances in which individuals practice HRBs is required in order for public health messages to be relevant and to resonate with the public (Garrett et al., 2015; Reid et al., 2010; Buck and Frosini, 2012; Watts et al., 2015).

5. Conclusions

Using data from two British birth cohorts we found more disadvantaged social circumstances in pre-adolescence strongly predicted more disadvantaged social circumstances in adulthood which had a proximal influence on HRB cluster membership. More disadvantaged social circumstances in adulthood decreased the likelihood of membership of the "Mainstream" cluster, characterised by more beneficial HRBs. The findings provide optimism for interventions relevant to reducing social gradients in HRBs because adult lifestyles are not likely to be fully determined by pre-adolescent social circumstances. Consistency across the cohorts implies the proximal social patterning of adult lifestyles may persist across time.

Conflict of interest

The authors declare there is no conflict of interest.

Acknowledgments

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Appendix A. Measures

Adult HRBs

Participants were asked if they smoked cigarettes and the average number smoked per day (range 0–80) those who reported not smoking cigarettes were coded as 0. Those reporting to smoke occasionally (BCS70 only, n = 645, 6.4%), were also coded as 0.

Alcohol consumption was measured according to average drinking frequency and the number of alcoholic beverages consumed in the previous

week. Beverage categories were combined to provide the total number of units consumed (1 unit = 8 g ethanol, range 0–210 units). This total was categorised according to consumption frequency and quantity, reflecting gender specific UK guidelines for 'safe' weekly consumption (DOH, 1995). Participants reporting 0 units in the previous week were coded as 'no units' alongside never and infrequent drinkers. Men reporting 1–21 units and women reporting 1–14 units were coded as 'within limits' as were frequent drinkers, reporting 0 units in the previous week. Men reporting > 21 units and women reporting > 14 units were coded as 'above limits'.

Participants were asked whether they regularly took part in leisure time physical activity, defined as "at least once a month, for most of the year", and the frequency; "every day", "4–5 days per week", "2–3 days per week", "once a week", "2–3 times a month", "less often". Responses with sparse data were combined, creating four categories; '≤3 times a month', 'Once a week', '2–3 days a week', '4–7 days a week'.

Diet was indicated by the average frequency of consumption of six variables; 'fruit'; 'vegetables'; 'chips'; 'fried foods'; 'sweets or chocolate'; 'biscuits' (NCDS), and 'biscuits or cakes' (BCS70). In both studies, participants were asked if they consumed these foods "more than once a day", "once a day", "3–6 days a week", "1–2 days a week", "less than 1 day a week" or "never". An additional "occasional" category, present in the BCS70, was combined with "less than 1 day a week". In the about BCS70 participant's diet was unavailable at age 34 and therefore taken at age 30 (CLS, 2016c).

Based on the findings from Principal Components Analysis, the six diet variables were combined to form three composite variables; 'fruit and vegetables', 'chips and fried food' (hereafter fried food) and 'sweets, chocolate, biscuits or cakes' (hereafter sweet food). Frequency scores (range 0 to 5) were added together, creating a score ranging from 0 (never) to 10 (more than once a day).

Pre-adolescent SEP

Indicators selected to capture pre-adolescent household economic circumstance were as follows: living in social housing ("yes", "no"), overcrowding ('up to 1 person per room', "1 person per room", ' > 1 to 1.5 people per room', ' > 1.5 to 2 people per room', ' > 2 people per room'), receiving free school meals ("yes", "no"), in receipt of benefits associated with disadvantage ("yes", "no") and in the BCS70 household income (' < £35 per week', '£35–49 per week', '£50–99 per week', '£100–149 per week', '£150–199 per week', '£200–249 per week', '≥£250 per week').

To capture cultural norms in the household, we used parental education and parental interest in their child's education. Parental education was measured according to whether parents remained in education past minimum school leaving age, either > 14 or > 15 (depending on the age of the parent) in the NCDS and > 15 in the BCS70 (Galindo-Rueda, 2003).[1] Parental interest in their child's education was assessed via the child's school teacher, at age 11 in the NCDS (CLS, 2014) and age 10 in the BCS70 (CLS, 2016b). Categories differed slightly across the cohorts (NCDS = 'over concerned', "very interested", 'some interest', 'little interest'; BCS70 = 'very interested', 'moderately interested', 'very little interest', 'uninterested').

Adult SEP

Indicators of economic circumstances in adulthood were: receiving benefits associated with disadvantage ("yes", "no"), living in social housing ("yes", "no"), owning a car ("yes", "no"), overcrowding ('up to 1 person per room', '1 person per room', ' > 1 to 1.5 people per room', ' > 1.5 people per room') and household income (log transformed weekly net income adjusting for household size using OECD square root method (Anyaegbu, 2010)). Information was taken at age 33 in the NCDS (CLS, 2008a) and age 34 in the BCS70 (CLS, 2016a), except for car ownership in the BCS70 which was taken from age 30 (CLS, 2016c) assuming little change in car ownership in 4 years.

Indicators relating to education and social prestige were selected to capture cultural norms in adulthood. Highest held qualification was taken at age 33 in the NCDS (CLS, 2008a) and age 34 in the BCS70 (CLS, 2016a), and based on academic and vocational qualifications ('no qualifications', 'CSE 2-5/NVQ1', 'O Level/NVQ2', 'A Level/NVQ3', 'Diploma or higher qualification below degree/NVQ4', 'Degree or higher/NVQ5 or 6').

Age the cohort member left full time education was taken at age 42 in the NCDS[2] and age 34 in the BCS70[3] and included as continuous.

We used the Cambridge scale, a validated measure of the social distance between the participant and individuals in other occupations (Prandy and Lambert, 2003). Participants own gender specific Cambridge scores (Prandy and Lambert, 2003) were included. If married or cohabiting, the spouse or partner Cambridge score was also included if higher.

In adulthood the three category National Statistics Socio-Economic Classification (NS-SEC) (ONS, 2010) captured employment relations, defined as 'higher managerial, administrative and professional', 'intermediate', 'routine and manual'. Information was taken at age 33 in the NCDS (CLS, 2008a) and age 34 in the BCS70 (CLS, 2016a). Unemployed participants were asked about their most recent employment experience and those never employed (NCDS unemployed = 39, permanently sick/disabled = 57, homemakers = 303, other = 42, BCS70 unemployed = 40, permanently sick/disabled = 143, homemakers = 474, other = 67) were coded missing on the premise that their HRBs would be captured by other SEP indicators.

In the NCDS employee benefits were: access to employer pension scheme, the chance to buy company shares, access to a company car, offered private medical insurance (all "yes", "no"). In the BCS70 they were: access to employer pension scheme, member of employer pension scheme (both 'yes', 'no').

Appendix B. Confirmatory Factor Analysis (CFA)

CFA was applied to derive conceptually validated SEP constructs in the path model. Fig. B1 is a diagram of the CFA model, representing the measurement part of the path model, describing how the indicator variables are conceived to be related to the SEP construct at each age.

[1] This information was taken from birth for mothers and age 7 for fathers in the NCDS and from age 5 for both parents in the BCS70. Cross-tabulations with parental education at age 16 found this to remain relatively stable over time.

[2] At age 42 in the NCDS, there was a small number of NCDS participants (n = 10) who reported to have left full time continuous education after age 33 yet assigned to the 'still in full time education' category. Most of those reporting to be in full time continuous education at age 42 (n = 206) were employed at age 33 (n = 175). These participants and those who did not have information at age 42 were either classified according to the age at which they started employment at age 23 (n = 1341) or coded as missing (n = 454).

[3] In the BCS70, the small number in full time continuous education at age 34 (n = 8) were coded as missing, most reported being employed and none reported being students.

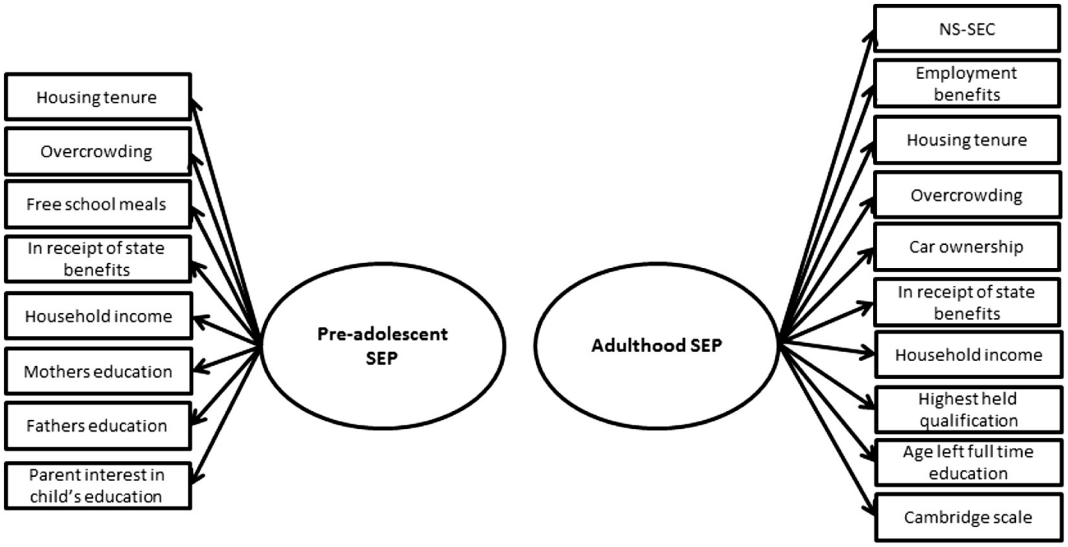

Fig. B1. The measurement part of the path models, demonstrating the relationship between indicator variables and pre-adolescent and adult SEP constructs in the NCDS and BCS70. Notes: SEP = socio-economic position. Ovals represent the latent variables. Rectangles represent the observed variables.

CFA and path model fit was assessed using the Comparative Fit Index (CFI) (Bentler, 1990) and the Root Mean Square Error of Approximation (RMSEA) (Steiger, 1990). Adequate model fit was determined by a CFI of > 0.9 and the RMSEA < 0.05 (Wang and Wang, 2012). Missing data for the SEP indicator variables was handled through pairwise deletion using the WLSMV estimator function (Muthén and Muthén, 2012). CFA models were run separately for men and women in each cohort in Mplus version 7 (Muthen, 2014).

Tables B1 and B2 present the results of the CFA models run separately for men and women in each cohort. The CFI was > 0.9 and the RMSEA was < 0.05 (Wang and Wang, 2012) for all CFA models. The Pearson r correlation between the pre-adolescent and adult SEP constructs was ≤0.75 in all CFA models, below the cut off criterion of 0.85 indicating discriminant validity (Kline, 2011).

In the CFA models, predictor variables with factor loadings > 0.32 and p values < 0.05 were considered to contribute moderately to the SEP construct that they were hypothesised to measure (Tabachnick et al., 2001). Indicators with weaker loadings (< 0.32) were also retained if they were significant for at least one gender group ($p < 0.05$). To improve model fit in the CFA models, measurement errors amongst six SEP indicators in the NCDS (see note 3, Table B1) and five SEP indicators in the BCS70 (see note 3, Table B2) were free to correlate, based upon model modification indices that were thought to be theoretically plausible, such as variables which were similar in wording and measurement (Wang and Wang, 2012). As can be seen in Tables B1 and B2 most indicators contributed at least moderately to their respective latent SEP construct (> 0.32). Those found to be weaker were still statistically significant ($p < 0.05$) and therefore retained.

Table B1
Estimates from CFA models incorporating both pre-adolescent and adult SEP indicator variables in the NCDS. Data: The National Child Development Study (NCDS) at age 0 (1958), 7 (1965), 11 (1969), 33 (1991) and 42 (2000).

	NCDS Men	NCDS Women
	Estimate (S.E)	Estimate (S.E)
Pre-adolescent indicator variables		
Housing tenure	0.69 (0.02)	0.67 (0.02)
Overcrowding	0.56 (0.02)	0.58 (0.02)
Free school meals	0.64 (0.03)	0.57 (0.04)
Benefits received	0.57 (0.03)	0.54 (0.04)
Mothers education	0.64 (0.02)	0.65 (0.03)
Fathers education	0.69 (0.02)	0.71 (0.02)
Parental interest in education	0.70 (0.02)	0.69 (0.02)
Adult indicator variables		
Housing tenure	0.76 (0.02)	0.78 (0.01)
Overcrowding	0.48 (0.03)	0.45 (0.02)
Car ownership	0.30 (0.03)	0.45 (0.02)
Benefits received	0.52 (0.03)	0.61 (0.01)
Household income	−0.48 (0.01)	−0.53 (0.01)
NS-SEC	0.79 (0.01)	0.75 (0.01)
Access to employer pension scheme	−0.27 (0.03)	−0.49 (0.02)
Chance to buy shares	−0.19 (0.02)	−0.01 (0.03)†
Access to company car	−0.41 (0.03)	−0.28 (0.03)
Private medical insurance	−0.43 (0.03)	−0.23 (0.03)
Highest held qualification	−0.76 (0.01)	−0.81 (0.01)
Age left full time education	−0.63 (0.01)	−0.66 (0.01)

Highest household Cambridge scale	−0.74 (0.01)	−0.72 (0.01)
Pearson r*	0.73	0.75

Note 1: Standardised factor loadings. All loadings statistically are significant ($p \leq 0.001$) except † = $p > 0.10$. Note 2: NCDS Men CFI = 0.939, RMSEA = 0.046, Chi-square (degrees of freedom) = 2490 (163), NCDS Women CFI = 0.946, RMSEA = 0.046, Chi-square (degrees of freedom) = 2507 (163). Note 3: 1) NS-SEC and highest household Cambridge scale; 2) Access to a company car and employer offering private medical insurance; 3) household income and employer offering private medical insurance; 4) the chance to buy shares in company and employer offering a pension scheme; 5) being in receipt of benefits and car ownership; 6) number of years in education and highest held qualification.

* Correlation between constructs of SEP.

Table B2
Estimates from CFA models incorporating both pre-adolescent and adult SEP indicator variables in the BCS70. Data: The British Cohort Study (BCS70) at age 5 (1985), 10 (1980), 30 (2000) and 34 (2004).

	BCS70 Men	BCS70 Women
	Estimate (S.E)	Estimate (S.E)
Pre-adolescent indicator variables		
Housing tenure	0.80 (0.02)	0.77 (0.01)
Overcrowding	0.47 (0.02)	0.46 (0.2)
Free school meals	0.63 (0.02)	0.68 (0.02)
Benefits received	0.59 (0.03)	0.65 (0.02)
Household income	−0.63 (0.01)	−0.70 (0.01)
Mothers education	0.70 (0.02)	0.65 (0.01)
Fathers education	0.76 (0.02)	0.71 (0.02)
Parental interest in education	0.56 (0.02)	0.56 (0.02)
Adult indicator variables		
Housing tenure	0.69 (0.02)	0.73 (0.02)
Overcrowding	0.45 (0.03)	0.48 (0.02)
Car ownership	0.12 (0.02)	0.32 (0.02)
Benefits received	0.48 (0.03)	0.61 (0.02)
Household income	−0.47 (0.01)	−0.53 (0.01)
NS-SEC	0.77 (0.01)	0.78 (0.01)
Access to employer pension scheme	0.30 (0.03)	0.36 (0.03)
Has an employer pension scheme	0.43 (0.02)	0.55 (0.02)
Highest held qualification	−0.74 (0.01)	−0.72 (0.01)
Age left full time education	−0.50 (0.01)	−0.41 (0.01)
Highest household Cambridge scale	−0.74 (0.01)	−0.72 (0.01)
Pearson r*	0.67	0.63

Note 1: Standardised factor loadings. All loadings are statistically significant ($p \leq 0.001$). Note 2: BCS70 Men CFI = 0.935, RMSEA = 0.049, Chi-square (degrees of freedom) = 2013 (146), BCS70 Women CFI = 0.940, RMSEA = 0.048, Chi-square (degrees of freedom) = 2080 (146). Note 3: 1) employer offering a pension scheme and cohort member joining a pension scheme; 2) receiving benefits in childhood and receiving free school meals; 3) living in social housing in adulthood and receiving benefits in adulthood; 4) NS-SEC and highest household Cambridge scale; 5) number of years in education and highest held qualification.

* Correlation between constructs of SEP.

Appendix C. Descriptive statistics for pre-adolescent and adult SEP indicator variables

Tables C1 and C2 present the descriptive statistics of the analytical sample in each cohort study. There were both similarities and differences in the distribution of pre-adolescence and adult SEP across the two cohorts.

In pre-adolescence, participants in the BCS70 appeared to be less materially disadvantaged compared to those in the NCDS. For example, the prevalence of overcrowding (< 1 person per room NCDS = 32.1%, BCS70 = 42.1%) and living in council housing (NCDS = 34.3%, BCS70 = 24.6%) was statistically lower in the later-born cohort ($p < 0.001$). In terms of the cultural dimension, a higher proportion of mothers and fathers stayed at school past minimum leaving age in the BCS70 compared to the NCDS (NCDS mothers = 23.1%, BCS70 mothers = 25.9%, $p < 0.001$; NCDS fathers = 19.7%, BCS70 fathers = 24.1%, $p < 0.001$).

For adulthood material dimension indicators, overall BCS70 participants tended to be more advantaged than NCDS participants. For example, mean income was higher for participants in adulthood in the BCS70 than in the NCDS (NCDS mean = 195.0 (sd 1090.7), BCS70 mean = 335.4 (sd 784), $p < 0.001$), after accounting for inflation.[4] In terms of occupation dimension indicators, the NCDS had a higher proportion of working-class participants compared to the BCS70 (NCDS = 39.3%, BCS70 = 29.3%, $p < 0.001$). Moreover, there was greater access to employer pension schemes in the BCS70 compared to the NCDS (NCDS = 42.2%, BCS70 = 58.1%, $p < 0.001$), particularly amongst women (NCDS = 33.0%, BCS70 = 54.2%, $p < 0.001$). For the cultural dimension, the distribution of qualifications in each cohort indicated increased homogeneity in the

[4] NCDS mean income in 1991 was £195, BCS70 mean income in 2004 was £335. After accounting for inflation, £195 in 1991 was equivalent to £249 in 2004 (calculated via http://www.whatsthecost.com/cpi.aspx).

BCS70 and the age left full-time education was higher in the BCS70 compared to the NCDS (NCDS mean = 17.2 (sd 2.1), BCS70 mean = 18.7 (sd 3.9), $p < 0.001$).

Table C1
Descriptive statistics for pre-adolescent SEP indicator variables. Data: two British birth cohort studies, the National Child Development Study (NCDS) at age 0 (1958), 7 (1965) and 11 (1969), the British Cohort Study (BCS70) at age 5 (1985) and 10 (1980).

Pre-adolescent SEP indicator variables	Total NCDS N = 11,373 (100%)	Men NCDS n = 5586 (100%)	Women NCDS n = 5787 (100%)	Total BCS70 n = 9464 (100%)	Men BCS70 n = 4613 (100%)	Women BCS70 n = 5033 (100%)
Housing tenure						
Owner occupied/private rent/tied to occupation/ other	5746 (50.5%)	2849 (51.0%)	2897 (50.1%)	6030 (62.5%)	2890 (62.7%)	3140 (62.4%)
Council rented	3903 (34.3%)	1893 (33.9%)	2010 (34.7%)	2368 (24.6%)	1111 (24.1%)	1257 (25.0%)
Missing	1724 (15.2%)	844 (15.1%)	880 (15.2%)	1248 (12.9%)	612 (13.3%)	636 (12.6%)
Overcrowding						
< 1 person per room	3649 (32.1%)	1820 (32.6%)	1829 (31.6%)	3870 (40.1%)	1810 (39.2%)	2060 (40.9%)
1 person per room	2423 (21.3%)	1195 (21.4%)	1228 (21.2%)	2288 (23.7%)	1093 (23.7%)	1195 (23.7%)
> 1 to 1.5 people per room	2553 (22.5%)	1222 (21.9%)	1331 (23.0%)	1785 (18.5%)	874 (19.0%)	911 (18.1%)
> 1.5 to 2 people per room	826 (7.3%)	400 (7.2%)	426 (7.4%)	314 (3.3%)	156 (3.4%)	158 (13.1%)
> 2 people per room	197 (1.7%)	102 (1.8%)	95 (1.6%)	109 (1.1%)	46 (1.0%)	63 (1.3%)
Missing	1726 (15.2%)	847 (15.2%)	878 (15.2%)	1280 (13.5%)	634 (13.7%)	646 (12.8%)
Free school meals						
No	8658 (76.1%)	4275 (76.5%)	4383 (75.7%)	7373 (76.4%)	3551 (77.0%)	3822 (75.9%)
Yes	876 (7.7%)	410 (7.3%)	466 (8.1%)	1042 (10.8%)	458 (9.9%)	584 (11.6%)
Missing	1839 (16.2%)	901 (16.1%)	938 (16.2%)	1231 (12.8%)	604 (13.1%)	627 (12.5%)
Benefits received						
No benefits	7245 (63.7%)	3539 (63.4%)	3706 (64.0%)	6053 (62.8%)	2914 (63.2%)	3139 (62.4%)
≥1 benefits	725 (6.4%)	348 (6.2%)	377 (6.5%)	818 (8.5%)	353 (7.7%)	465 (9.2%)
Missing	3403 (29.9%)	1699 (30.4%)	1704 (29.4%)	2775 (28.8%)	1346 (29.2%)	1429 (28.4%)
Weekly gross household income (BCS70 only)						
< £35 per week	N/A	N/A	N/A	120 (1.2%)	59 (1.3%)	61 (1.2%)
£35–£49 per week				307 (3.2%)	137 (3.0%)	170 (3.4%)
£50–£99 per week				2200 (22.8%)	1025 (22.2%)	1175 (23.4%)
£100–£149 per week				2753 (28.5%)	1322 (28.7%)	1431 (28.4%)
£150–£199 per week				1344 (13.9%)	659 (14.3%)	685 (13.6%)
£200–£249 per week				539 (5.6%)	250 (5.4%)	289 (5.7%)
> £249 per week				497 (5.2%)	246 (5.3%)	251 (5.0%)
Missing				1886 (19.6%)	915 (19.8%)	971 (19.3%)
Mothers education						
Stayed past minimum school leaving age	2622 (23.1%)	1288 (24.8%)	1334 (23.1%)	2494 (25.9%)	1177 (25.5%)	1317 (26.2%)
Did not stay past minimum school leaving age	7486 (65.8%)	3683 (71.0%)	3803 (65.7%)	5055 (52.4%)	2419 (52.4%)	2636 (52.4%)
Missing	1265 (11.1%)	615 (11.0%)	650 (11.2%)	2097 (21.7%)	1017 (22.1%)	1080 (21.5%)
Fathers education						
Stayed past minimum school leaving age	2237 (19.7%)	1085 (19.4%)	1152 (19.9%)	2325 (24.1%)	1103 (23.9%)	1222 (24.3%)
Did not stay past minimum school leaving age	6913 (60.8%)	3412 (61.1%)	3501 (60.5%)	4899 (50.8%)	2358 (51.1%)	2541 (50.5%)
Missing	2223 (19.5%)	1089 (19.5%)	1134 (19.5%)	2422 (25.1%)	1152 (25.0%)	1270 (25.2%)
Parental interest in education						
Over concerned (NCDS only)	209 (1.8%)	107 (1.9%)	102 (1.8%)	N/A	N/A	N/A
Very interested	3282 (28.9%)	1558 (27.9%)	1724 (29.8%)	3710 (38.5%)	1736 (37.6%)	1974 (39.2%)
Some interest (NCDS)/ moderately interested (BCS70)	3631 (31.9%)	1806 (32.3%)	1825 (31.5%)	2589 (26.8%)	1248 (27.1%)	1341 (26.6%)
Little (NCDS)/very little interest (BCS70)	1708 (15.0%)	890 (15.9%)	818 (14.1%)	387 (4.0%)	198 (4.3%)	189 (3.8%)
Uninterested (BCS70)	N/A	N/A	N/A	220 (2.3%)	117 (2.5%)	103 (2.1%)
Missing	2543 (22.4%)	1225 (21.9%)	1318 (22.8%)	2740 (28.4%)	1314 (28.5%)	1426 (28.3%)

Table C2
Descriptive statistics for adult SEP indicator variables. Data: two British birth cohort studies, the National Child Development Study (NCDS) at age 33 (1991) and 42 (2000), the British Cohort Study (BCS70) at age 30 (2000) and 34 (2004).

Adult SEP indicator variables	Total NCDS N = 11,373 (100%)	Men NCDS n = 5586 (100%)	Women NCDS n = 5787 (100%)	Total BCS70 n = 9464 (100%)	Men BCS70 n = 4613 (100%)	Women BCS70 n = 5033 (100%)
Housing tenure						
Owner occupied/private rent/other	8849 (77.8%)	4325 (77.4%)	4524 (78.2%)	8551 (88.7%)	4194 (90.9%)	4357 (86.6%)
Council rented	1588 (14.0%)	669 (12.0%)	919 (15.9%)	1049 (10.9%)	397 (8.6%)	652 (13.0%)
Missing	936 (8.2%)	592 (10.6%)	344 (5.9%)	46 (0.5%)	22 (0.5%)	24 (0.5%
Overcrowding						
< 1 person per room	7486 (65.8%)	3714 (66.5%)	3772 (65.2%)	7279 (75.5%)	3534 (76.6%)	3745 (74.4%)
1 person per room	2366 (20.8%)	1153 (20.6%)	1213 (21.0%)	1579 (16.4%)	730 (15.8%)	849 (16.9%)
> 1 to 1.5 people per room	1142 (10.0%)	512 (9.2%)	630 (10.9%)	634 (6.6%)	282 (6.11%)	352 (7.0%)
> 1.5 people per room	149 (1.31%)	69 (1.2%)	80 (1.4%)	92 (1.0%)	33 (0.8%)	59 (1.2%)
Missing	230 (2.0%)	138 (2.5%)	92 (1.6%)	62 (0.6%)	34 (0.7%)	28 (0.6%)
Car ownership						
Yes	9658 (84.9%)	4759 (85.2%)	4899 (84.7%)	6934 (71.9%)	3353 (72.7%)	3581 (71.2%)
No	1604 (14.1%)	779 (14.0%)	825 (14.3%)	2040 (21.2%)	864 (18.7%)	1176 (23.4%)
Missing	111 (1.0%)	48 (0.9%)	63 (1.09%)	672 (7.0%)	396 (8.6%)	276 (5.5%)
Benefits received						
No benefits	10,160 (89.3%)	5096 (91.2%)	5064 (87.5%)	8929 (92.6%)	4353 (94.4%)	4576 (90.9%)
≥1 benefits	1165 (10.2%)	467 (8.4%)	698 (12.1%)	703 (7.3%)	253 (5.5%)	450 (8.9%)
Missing	48 (0.4%)	23 (0.4%)	25 (0.4%)	14 (0.2%)	7 (0.2%)	7 (0.1%)
NS-SEC						
Higher managerial, administrative and professional	3558 (31.3%)	1998 (35.8%)	1560 (27.0%)	4136 (42.9%)	2132 (46.2%)	2004 (39.8%)
Intermediate	2677 (23.5%)	1043 (18.7%)	1634 (28.2%)	1949 (20.2%)	830 (18.0%)	1119 (22.2%)
Routine and manual	4473 (39.3%)	2328 (41.7%)	2145 (37.1%)	2823 (29.3%)	1515 (32.8%)	1308 (26.0%)
Missing	665 (5.9%)	217 (3.9%)	448 (7.7%)	738 (7.7%)	136 (3.0%)	602 (12.0%)
Access to employer pension scheme						
Yes	4797 (42.2%)	2887 (51.7%)	1910 (33.0%)	5604 (58.1%)	2874 (62.3%)	2730 (54.2%)
No	2605 (22.9%)	997 (17.9%)	1608 (27.8%)	1377 (14.3%)	715 (15.5%)	662 (13.2%)
Missing	3971 (34.9%)	1702 (30.5%)	2269 (39.2%)	2665 (27.6%)	1024 (22.2%)	1641 (32.6%)
Has joined employer pension scheme (BCS70 only)						
Yes	N/A	N/A	N/A	5461 (56.6%)	2920 (63.3%)	2541 (50.5%)
No				1554 (16.1%)	680 (14.7%)	874 (17.4%)
Missing				2631 (27.3%)	1013 (22.0%)	1618 (32.2%)
Chance to buy shares (NCDS only)						
Yes	1841 (16.2%)	1184 (21.2%)	657 (11.4%)	N/A	N/A	N/A
No	5561 (48.9%)	2700 (48.3%)	2861 (49.4%)			
Missing	3971 (34.9%)	1702 (30.5%)	2269 (39.2%)			
Access to company car (NCDS only)						
Yes	1295 (11.4%)	1058 (18.9%)	237 (4.1%)	N/A	N/A	N/A
No	6107 (53.7%)	2826 (50.6%)	3281 (56.7%)			
Missing	3971 (34.9%)	1702 (30.5%)	2269 (39.2%)			
Private medical insurance (NCDS only)						
Yes	1366 (12.0%)	964 (17.3%)	402 (7.0%)	N/A	N/A	N/A
No	6036 (53.1%)	2920 (52.3%)	3116 (53.8%)			
Missing	3971 (34.9%)	1702 (30.5%)	2269 (39.2%)			
Highest held qualification						
No qualifications	1402 (12.3%)	619 (11.1%)	783 (13.5%)	899 (9.3%)	486 (10.5%)	413 (8.2%)
CSE 2-5/NVQ1	1386 (12.2%)	607 (10.9%)	779 (13.5%)	1457 (15.1%)	703 (15.2%)	754 (15.0%)
O level/NVQ2	3803 (33.4%)	1669 (29.9%)	2134 (36.9%)	3173 (32.9%)	1539 (33.4%)	1634 (32.5%)
A level/NVQ3	1567 (13.8%)	1000 (17.9%)	567 (9.8%)	884 (9.2%)	417 (9.0%)	467 (9.3%)
Diploma or higher qualification below degree/NVQ4	1577 (13.9%)	785 (14.1%)	792 (13.7%)	2605 (27.0%)	1167 (25.3%)	1438 (28.6%)
Degree or higher/NVQ5 or 6	1401 (12.3%)	770 (13.8%)	631 (10.9%)	606 (6.3%)	291 (6.3%)	315 (6.3%)
Missing	237 (2.1%)	136 (2.4%)	101 (1.8%)	22 (0.2%)	10 (0.2%)	12 (0.2%)

	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)
Age left full time education (range 14 to 33/34)	17.22 (2.1)	17.2 (2.3)	17.2 (2.1)	18.7 (3.9)	18.6 (3.9)	18.7 (3.9)
Missing	454 (4.0%)	259 (4.6%)	195 (3.4%)	22 (0.2%)	12 (0.3%)	10 (0.2%)
Highest household Cambridge scale (range 10 to 99)	55.3 (14.8)	54.0 (14.6)	56.7 (14.9)	58.5 (13.9)	57.1 (13.9)	59.9 (13.7)
Missing	647 (5.7%)	205 (3.7%)	442 (7.6%)	749 (7.8%)	142 (3.08%)	607 (12.1%)
Weekly net household income adjusted for household size (range £0 to £90,000)	195.0 (1090.7)	209.8 (1516.0)	181.7 (419.1)	335.4 (784.0)	353.0 (946.2)	319.4 (600.0)
Missing	1683 (14.8%)	937 (16.8%)	746 (12.9%)	1493 (15.5%)	736 (16.0%)	757 (15.0%)

Appendix D. Pre-adolescent SEP strengthens the effect of adult SEP on HRB cluster membership

In order to explore the potential reasons for inconsistent mediation (MacKinnon et al., 2000), found amongst men, estimates from three multinomial logistic regression models were compared. The analysis was undertaken in Mplus Version 7 (Muthen, 2014). HRB cluster membership was included here as a three-category nominal variable. The first two models included each SEP construct (i.e. one in pre-adolescence and one in adulthood) as the sole predictor of HRB cluster membership. The third model included both SEP constructs.

The estimates in Tables D1 and D2 provide the results of these multinomial logistic regression models. The results demonstrate that amongst men in both cohorts the logit coefficient for adult SEP as a predictor of "Mainstream" comparative to 'Moderate Smokers' cluster membership increases following the inclusion of pre-adolescent SEP in the model (NCDS Men before = 1.73 (95% CI 1.58, 1.98), after = 2.33 (95% CI 2.05, 2.62); BCS70 Men before = 1.95 (95% CI 1.76, 2.15), after = 2.38 (95% CI 2.10, 2.67)). This suggests that the inclusion of pre-adolescent SEP in these models improves the contribution of adult SEP on HRB cluster membership, which is consistent with other descriptions of the enhancement effect (Sharpe and Roberts, 1997).

Moreover, the results demonstrate that the pre-adolescent SEP coefficient changes from positive to negative when adjusting for adult SEP (NCDS Men before = 0.84 (95% CI 0.74, 0.93), after = −0.46 (95% CI -0.64, −0.27); BCS70 Men before = 0.61 (95% CI 0.52, 0.71), after = −0.28 (95% CI -0.42, −0.14)). The same effect was found comparing 'Risky' and 'Mainstream' cluster membership amongst men in the NCDS SEP (before = 1.60 (95% CI 1.17, 2.03), after = −0.95 (95% CI -1.86, −0.04)). These results add support to the assertion that pre-adolescence strengthens the effect of adult SEP on HRB cluster membership.

In substantive terms, this implies that differentials in HRB patterns associated with social circumstances in adulthood are strengthened through the accumulation of either advantaged or disadvantaged social circumstances from pre-adolescence.

Table D1
Estimates from multinomial logistic regression models with and without pre-adolescent and adult SEP in the NCDS.

SEP estimated constructs	NCDS Men sample N = 5586 Logit coefficient (CI)			NCDS Women sample N = 5787 Logit coefficient (CI)		
	Mainstream (n = 3811)	Risky (n = 96)	Moderate Smokers (n = 1679)	Mainstream (n = 3972)	Risk (n = 561)	Moderate Smokers (n = 1253)
Pre-adolescent SEP only	Ref	1.60 (1.17, 2.03)**	0.84 (0.74, 0.93)**	Ref	2.50 (2.27, 2.75)**	0.72 (0.60, 0.83)**
Adult SEP only	Ref	3.67 (2.87, 4.48)**	1.73 (1.58, 1.89)**	Ref	4.56 (4.10, 5.03)**	1.23 (1.05, 1.40)**
Pre-adolescent SEP (adjusting for adult SEP)	Ref	−0.95 (−1.86, −0.04)**	−0.46 (−0.64, −0.27)**	Ref	0.73 (0.30, 1.16)*	0.12 (−0.10, 0.34)
Adult SEP (adjusting for pre-adolescent SEP)	Ref	4.98 (3.49, 6.47)**	2.33 (2.05, 2.62)**	Ref	3.55 (2.77, 4.32)**	1.08 (0.74, 1.41)**

* p value < 0.05.
** p value < 0.001.

Table D2
Estimates from multinomial logistic regression models with and without pre-adolescent and adult SEP in the BCS70.

SEP estimated constructs	BCS70 Men sample N = 4613 Logit coefficient (CI)			BCS70 Women sample N = 5033 Logit coefficient (CI)		
	Mainstream (n = 3410)	Risky (n = 79)	Moderate Smokers (n = 1292)	Mainstream (n = 3866)	Risky (n = 183)	Moderate Smokers (n = 984)
Pre-adolescent SEP only	Ref	1.79 (1.44, 2.13)**	0.61 (0.52, 0.71)**	Ref	1.97 (1.65, 2.30)**	0.69 (0.59, 0.80)**
Adult SEP only	Ref		1.95 (1.76, 2.15)**	Ref		1.86 (1.65, 2.07)**

		5.26 (4.25, 6.27)**			5.15 (4.35, 5.95)**	
Pre-adolescent SEP (adjusting for adult SEP)	Ref	0.25 (−0.28, 0.78)	−0.28 (−0.42, −0.14)**	Ref	0.50 (−0.02, 1.02)*	−0.01 (−0.17, 0.17)
Adult SEP (adjusting for pre-adolescent SEP)	Ref	4.79 (3.45, 6.16)**	2.38 (2.10, 2.67)**	Ref	4.38 (3.31, 5.45)**	1.87 (1.54, 2.19)**

* p value < 0.05.
** p value < 0.001.

Appendix E. Sensitivity analysis comparing estimates from multinomial logistic regression models that did and did not adjust for classification error

Table E1
Effect of pre-adolescent and adult SEP on HRB cluster membership in the NCDS using multinomial logistic regression.

SEP estimated constructs	NCDS Men sample N = 5586 Logit coefficient (CI)					
	Mainstream[a] (n = 3811)	Mainstream[b] (n = 3818)	Risky[a] (n = 96)	Risky[b] (n = 82)	Moderate Smokers[a] (n = 1679)	Moderate Smokers[b] (n = 1686)
Pre-adolescent SEP	Ref	Ref	−0.95 (−1.86, −0.40)	−0.90 (−1.62, −0.18)*	−0.46 (−0.64, −0.27)**	−0.46 (−0.64, −0.28)**
Adult SEP	Ref	Ref	4.98 (3.49, 6.47)**	4.54 (3.36, 5.73)**	2.33 (2.05, 2.62)**	2.35 (2.07, 2.63)**
SEP estimated constructs	NCDS Women sample N = 5787 Logit coefficient (CI)					
	Mainstream[a] (n = 3972)	Mainstream[b] (n = 3980)	Risky[a] (n = 561)	Risky[b] (n = 515)	Moderate Smokers[a] (n = 1253)	Moderate Smokers[b] (n = 1292)
Pre-adolescent SEP	Ref	Ref	0.73 (0.30, 1.16)*	0.61 (0.31, 0.91)**	0.12 (−0.10, 0.34)	0.18 (−0.02, 0.37)
Adult SEP	Ref	Ref	3.55 (2.77, 4.32)**	2.77 (2.26, 3.28)**	1.08 (0.74, 1.41)**	1.27 (0.97, 1.56)**

[a] Adjustment for classification error in the model.
[b] No adjustment for classification error in the model.
* p value < 0.05.
** p value < 0.001.

Table E2
Effect of pre-adolescent and adult SEP on HRB cluster membership in the BCS70 using multinomial logistic regression.

SEP estimated constructs	BCS70 Men sample N = 4613 Logit coefficient (CI)					
	Mainstream[a] (n = 3404)	Mainstream[b] (n = 3410)	Risky[a] (n = 94)	Risky[b] (n = 79)	Moderate Smokers[a] (n = 1116)	Moderate Smokers[b] (n = 1292)
Pre-adolescent SEP	Ref	Ref	0.25 (−0.28, 0.76)	0.17 (−0.28, 0.62)	−0.28 (−0.42, −0.14)**	−0.27 (−0.41, −0.13)*
Adult SEP	Ref	Ref	4.79 (3.45, 6.13)**	4.14 (3.10, 5.19)**	2.38 (2.10, 2.67)**	2.41 (2.13, 2.70)**
SEP estimated constructs	BCS70 Women sample N = 5033 Logit coefficient (CI)					
	Mainstream[a] (n = 3862)	Mainstream[b] (n = 3866)	Risky[a] (n = 224)	Risky[b] (n = 183)	Moderate Smokers[a] (n = 947)	Moderate Smokers[b] (n = 984)
Pre-adolescent SEP	Ref	Ref	0.50 (−0.02, 1.02)	0.33 (0.01, 0.65)	−0.01 (−0.17, 0.16)	0.03 (−0.11, 0.18)
Adult SEP	Ref	Ref	4.38 (3.31, 5.45)**	3.54 (2.87, 4.21)**	1.87 (1.54, 2.19)**	2.02 (1.72, 2.31)**

[a] Adjustment for classification error in the model.
[b] No adjustment for classification error in the model.
* p value < 0.05.
** p value < 0.001.

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