The association of attention deficit hyperactivity disorder with socioeconomic disadvantage: alternative explanations and evidence

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Background: Studies throughout Northern Europe, the United States and Australia have found an association between childhood attention deficit hyperactivity disorder (ADHD) and family socioeconomic disadvantage. We report further evidence for the association and review potential causal pathways that might explain the link. Method: Secondary analysis of a UK birth cohort (the Millennium Cohort Study, N = 19,519) was used to model the association of ADHD with socioeconomic disadvantage and assess evidence for several potential explanatory pathways. The case definition of ADHD was a parent-report of whether ADHD had been identified by a medical doctor or health professional when children were 7 years old. Results: ADHD was associated with a range of indicators of social and economic disadvantage including poverty, housing tenure, maternal education, income, lone parenthood and younger motherhood. There was no evidence to suggest childhood ADHD was a causal factor of socioeconomic disadvantage: income did not decrease for parents of children with ADHD compared to controls over the 7-year study period. No clinical bias towards labelling ADHD in low SES groups was detected. There was evidence to suggest that parent attachment/family conflict mediated the relationship between ADHD and SES. Conclusion: Although genetic and neurological determinants may be the primary predictors of difficulties with activity level and attention, aetiology appears to be influenced by socioeconomic situation. Keywords: ADHD, child development, longitudinal studies, social class, sociocultural influence.

Introduction

Childhood attention deficit hyperactivity disorder (ADHD) has been reported to be more prevalent among socioeconomically disadvantaged groups in many regions of the developed world. Studies from the United States (Akinbami, Liu, Pastor, & Reuben, 2011; Froehlich et al., 2007; Pastor & Rueben, 2008; St Sauver et al., 2004), the United Kingdom (Ford, Collishaw, Meltzer, & Goodman, 2007) and Scandinavian countries (Bæ, Øverland, Lundervold, & Hysing, 2012; Hjern, Weitoft, & Lindblad, 2010; Paananen et al., 2012), as well as in Australia (Sciberras, Ukoumunne, & Efron, 2011) and Germany (Döpfner, Breuer, Wille, Erhart, & Ravens-Sieberer, 2008), have all found an association between increased childhood ADHD or behavioural symptoms of ADHD and socioeconomic disadvantage. A recent systematic review, although focused on treatments for ADHD, noted that both symptoms and diagnosis of ADHD are more common among those from a low socioeconomic status (SES) background (Charach et al., 2011).

ADHD is diagnosed when a child demonstrates inattentive, hyperactive and impulsive behaviours in multiple settings which cause functional impairment (American Psychiatric Association, 2013). Potential explanations for the association can be classified into two types. First ‘real’ effects: in lower socioeconomic groups children truly have higher symptom levels. Second, ‘labelling’ effects: greater awareness and access to health care in some groups or differential reporting about the same level of difficulties between groups (Boyle et al., 2011). Figure 1 provides a schematic illustration of the causal pathways that may explain the link between childhood ADHD and low SES.

Proponents of health inequalities models have tended to position disease as an effect of socioeconomic disadvantage (Najman et al., 2004), often operating through differential exposure (Pathways 1 and 2, Figure 1). In this pathway, higher rates of ADHD in groups with greater socioeconomic disadvantage are mediated through differential exposure. Such exposures could be perinatal, prenatal or occur during childhood. A systematic review of pre- and perinatal risk factors for ADHD only implicated exposure to tobacco smoke in utero as a suspected risk factor (Linnet et al., 2003). Several studies have shown association between smoking in pregnancy and increased risk of ADHD (Schothorst & Van Engeland, 1996; Thapar et al., 2003) although other research suggests genetic and socioeconomic confounders partially or entirely account for the effect (e.g. Lindblad & Hjern, 2010).

Exposures later in childhood have also been linked to ADHD phenotypes and socioeconomic disadvantage; for example, numerous studies have...

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Socioeconomic status and children with ADHD

1. Are parental relationships more likely to dissolve after childhood ADHD has been identified?
2. Does family income decrease for families with a child with ADHD relative to those with a child without?

It was also possible to check for labelling effects through comparison of parent-reported symptom levels with identification by health professional/diagnosis (Pathways 6/7):

1. Do doctors and health professionals diagnose ADHD more often in socioeconomically deprived...
groups, compared to parent and teacher reports of ADHD symptoms?

Finally, two risk factors consistently implicated in the literature were tested for mediating effects. These were smoking in pregnancy (an early environmental exposure representing Pathway 1) and lack of parent attachment/family conflict (an example of later ‘exposure’ or differential family context, representing Pathway 2). The questions raised were:

1. Does low SES mean that mothers are more likely to smoke in pregnancy, leading to greater rates of ADHD?
2. Does low SES affect parenting adversely, increasing the odds of a child having ADHD?

These exposures were intended to be illustrative examples of plausibility of mediation by differential exposure to risk factors as a pathway from socioeconomic disadvantage to ADHD.

Methods
Sample

The MCS has followed 19,519 UK children, born between 2000 and 2002, via surveys and direct cognitive testing, carried out by trained interviewers face-to-face in family homes. Information was gathered from the first MCS survey when children were 9 months old, and three, five and 7 years of age: four sweeps of data collection. Informed parental consent was obtained at each stage of the study; the MCS ethical review gives details (Shepherd, 2012). Sample design in MCS was geographically clustered and disproportionately stratified to oversample children from ethnic minorities, and disadvantaged neighbourhoods (details of sample design are in Hansen, 2012). Attrition is a problem common to all longitudinal cohorts and oversampling was used to ensure adequate representation of the population at later ages (Plewis, 2007). Standardised weightings were applied to make the data representative of the UK population, and these adjusted results for the effects of attrition by age 7: approximately 72% of participating families were responding by this stage. We excluded children who had a statement of special needs (n = 318) as a proxy for other disorders (i.e. children with autism, hearing problems, conduct disorder were likely to have statements) because being diagnosed with alternative problems could confound the relationship between ADHD and SES (as symptoms of other disorders often co-occur with hyperactivity and some are linked to SES). Children who were twin or triplet siblings were also omitted as the study was underpowered to examine within-family variance. At sweep 4, the mean age was 7.2 years (SD = 0.2; age range = 6.3–8.2). The included sample size in this study who had reported on their child’s ADHD status was 13305.

Details of fieldwork, coding and questionnaires for MCS measures used are documented at length by Hansen (2012). Extensive documentation and all questionnaires used to generate MCS data are freely available, together with the dataset itself, and can be accessed via the MCS website. The MCS is an ongoing resource, and data collected at further sweeps will be released regularly as children mature.

Measure of ADHD diagnosis

Parent-reports of ADHD diagnosis by a medical doctor or health professional were taken as ADHD case definition (n = 187). This measure has been used to estimate the prevalence of ADHD (Akinbami et al., 2011; Pastor & Rueben, 2008) using US data from National Health Interview Survey (NHIS). The MCS used an adapted version of the NHIS question to record ADHD status: during face-to-face interviews, parents or carers were asked:

1. Has a doctor or health professional ever told you that (sample child) had attention deficit hyperactivity disorder (ADHD)?

In line with other studies (e.g. Boyle et al., 2011) a positive answer to the above question was taken as representative of ADHD diagnosis. Families who answered ‘don’t know’ or refused to answer were excluded from the analysis. In MCS, after weighting, 1.5% of children were reported as having been identified/diagnosed with ADHD by sweep 4 in MCS (Russell, Rodgers, Ukoumunne & Ford, 2013).

Measures of SES

Measures of socioeconomic status taken at all sweeps included parents’ highest educational qualification, social class (NS-SEC seven class structure; Office for National Statistics, ONS, 2013), family size and type of housing tenure: in the United Kingdom, social housing is let at low rents and on a secure basis to people in housing need. Equivalised family income was measured at each sweep (adjusted for the number of children per family), with households classed as living in poverty at sweep 4 if their income was equal to or less than 60% of the median household income for the United Kingdom, the definition of poverty set by the UK government (below £236 per week). Family structure (either lone parent or couple) was reported at each sweep. Married couples were more economically advantaged in MCS than lone parent families (Kiernan & Mensah, 2009). The first MCS survey recorded the children’s birth weight from the UK Birth Registration and Maternity Hospital Episode Data and the age of mother at childbirth. An ‘index of SES’ was also created from variables measured at sweep 1 that were relatively stable over time: fathers’ social class, mothers’ social class and paternal and maternal education. To test tobacco use in utero as a mediator, it was necessary
to assume the SES index would have preceded pregnancy 18 months previously (assumption of stability; Cole & Maxwell, 2003). The index of SES was calculated by taking the mean values of these measures using an incremental score of 1 for each decrease in rank. If data were missing, the mean across the number of variables for which valid data were recorded was taken. As a check, we generated a second SES index from factor analysis of the same measures (one factor resulted). Correlation between these two indices of SES was 99.5%.

**Risk factors**

Records of whether mothers smoked during pregnancy were taken when children were aged 9 months old. Pregnant mothers were classified as smokers or non-smokers. Missing data were not analysed. The Child–Parent Relationship Scale (CPRS) adapted from the Student–Teacher Relationship Scale (Pianta, 1995) was used to measure attachment. The CPRS is a 15 item self-administered rating scale, with responses on a 5-point Likert scale. Items were derived from attachment theory and the attachment Q-set (Waters & Dean, 1985). The items involve the respondent’s feelings and beliefs about the relationship with the child, and about the child’s behaviour towards the parent. CPRS was measured in MCS sweep 2 (mean age children = 3.1 years, SD = 0.2) and used to generate ‘Conflict’ and ‘Closeness’ scores. The ‘closeness’ score was reversed and scores were combined to create a family conflict/distant parent score. Approximately 98% of respondents were mothers.

**Symptoms of ADHD**

The Strengths and Difficulties Questionnaire (SDQ) is a behavioural screening questionnaire for children aged 4–16 (Goodman, 2001) that includes a subscale for hyperactivity-inattention and the accompanying impact of problematic behaviours. The SDQ was administered to both parents and teachers at sweep 4 in MCS. The four measures of SDQ teacher/parent-reported hyperactivity-inattention and impact for each child were considered as an indicative of ADHD symptoms as they have been strongly correlated with ADHD in several other studies (e.g. Ullebo, Posserud, Heiervang, Gillberg, & Obel, 2011). Children’s clinicians were not informed of SDQ research ratings.

**Analysis**

First, the association between the outcome of ADHD diagnosis and a range of indicators of socioeconomic disadvantage, including maternal education level, poverty, income, lone parenthood, family size, birth weight, being a younger mother, and index of SES was established using logistic regression. Standar-
product of coefficients, using bootstrapping (300 replications) to estimate bias corrected confidence intervals (CIs), as recommended by Preacher and Hayes (2008). Figure 3 (in results section) illustrates the causal pathways tested. The indirect effects and direct effect add up to the total effect. The coefficients were standardised to compare direct and indirect effects. The Stata command for binary mediation (Ender, 2011) was used to calculate the indirect effects. This employs a combination of linear regression with logit models. Where the CIs from the indirect effects (the effect of the predictor on the outcome via the mediator) do not cross zero, the analysis provided evidence that mediation had occurred.

Results
ADHD was strongly associated with a range of indicators of social and economic disadvantage in this cohort, including poverty, housing tenure, income, lone parenthood, index of SES and being a younger mother. Table 1 shows descriptive statistics for families who have cohort children with and without a diagnosis of ADHD.

As Table 1 illustrates, a larger proportion of children with ADHD diagnosis came from families below the poverty line than in the UK population as a whole. The mean equivalised income for households with an ADHD study child was £324 per week as opposed to £391 for families without a child with ADHD diagnosis, and the odds of parents who owned their own houses having children with ADHD were roughly a third the odds for those who were in social housing. The mean age of mothers at delivery was 26 years for children who would later have ADHD diagnosis and 28 years for the rest of the population. The odds of having a child with ADHD were higher for younger mothers. Mothers with no qualifications were more than twice as likely to have children with ADHD than those with degrees. Lone parents were more likely to have children with ADHD diagnosis than those families with two live-in parents. Greater socioeconomic disadvantage as measured by the index of SES was also associated with ADHD. There was no association between ADHD and birth weight or family size in MCS.

Checking for reverse causality
Change in income over time for families with and without a study child with ADHD was plotted (Figure 2). Overall, income showed a linear trend to increase over time, with income increasing on average £13.93 per year per family who had a child with ADHD (95% CI 8.66–19.19; p < .001), and £10.99 for the rest of the sample (95% CI 9.92–12.06; p < .001). As Figure 2 illustrates, there was no evidence of a comparative decrease in income over time for families with a child with ADHD compared to those

Table 1 The association of indicators of socioeconomic disadvantage with ADHD in the Millennium Cohort

| Socio-demographic factors          | Mean/% Unadjusted | 95% CIelligence | p     |
|-----------------------------------|-------------------|-----------------|-------|
| Birth weight (kg)                 | ADHD | 3.32 | 3.37 | 0.86 (0.62,1.19) | 0.369 |
| Maternal (years) age at childbirth| ADHD | 26.22 | 28.45 | 0.94 (0.91, 0.97) | <0.001 |
| Family income (£ per week) – sweep 4d | ADHD | 324 | 391 | 0.23 (0.94, 0.55) | 0.001 |
| Family size: overall – sweep 4d  | ADHD | 19 | 13 | Referent | 0.121 |
| Only child                        | ADHD | 38 | 46 | 0.55 (0.34, 0.90) | <0.001 |
| 1 sibling                         | ADHD | 27 | 27 | 0.68 (0.40, 1.14) | <0.001 |
| 2 siblings                        | ADHD | 16 | 14 | 0.78 (0.45, 1.34) | <0.001 |
| Maternal education: overall       | ADHD | 28 | 17 | Referent | 0.009 |
| No qualifications                 | ADHD | 59 | 58 | 0.61 (0.40, 0.93) | <0.001 |
| School level                      | ADHD | 13 | 26 | 0.32 (0.18, 0.55) | <0.001 |
| Degree or higher                  | ADHD | 60 | 71 | Referent | 0.099 |
| Poverty                           | ADHD | 40 | 29 | 1.65 (1.13, 2.41) | <0.001 |
| Family structure                  | ADHD | 63 | 78 | Referent | 2.07 (1.42, 3.03) | <0.001 |
| Two parent family – sweep 4       | ADHD | 37 | 22 | Referent | 0.001 |
| Single parent family              | ADHD | 5 | 10 | 0.80 (0.45,1.41) | <0.001 |
| Housing tenure – sweep 4: overall | ADHD | 42 | 65 | 0.37 (0.26,0.53) | <0.001 |
| Social housing,%                  | ADHD | 44 | 25 | Referent | 1.29 (1.15, 1.45) | <0.001 |
| Rent private,%                    | ADHD | 14 | 10 | 0.80 (0.45,1.41) | <0.001 |
| Home owner,%                      | ADHD | 42 | 65 | 0.37 (0.26,0.53) | <0.001 |

*a* includes all children without diagnosis of ADHD, and without Statement of Special Educational Needs.

*b* number of observations ranges from 11655 to 13305, scores not standardised therefore Odds Ratios (OR) not directly comparable.

*c* OR shows decreased chances of having ADHD per £1000 increase in weekly income.

*d* For all categorical variables, as the odds of being in the reference category are 1.

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without. In fact, there was a slight increase in income for families with a child with ADHD, compared to the rest of the population over the 7-year period, but the difference in income increase was not significant. Results provided no evidence to support the reverse causality model in relation to loss of income.

After propensity score matching, change in income with time was also not significantly different between the two groups. Control families’ initial average weekly income was £244 as opposed to £249 for families with a child with ADHD. Over the 7-year study period, income increased by £11.63 per year (95% CI, 7.13–16.13) for controls. Families with a child with ADHD child did slightly better, as noted above, although confidence intervals overlapped substantially.

According to the reverse causality hypothesis, a child with ADHD might put additional strain on family resources leading to increase in marital breakup. ADHD is rarely identified before age 3; hyperactive and inattentive behaviours are highly prevalent, and considered ‘normal’ in many toddlers, not just those who go on to a diagnosis of ADHD (Einarsdottir, 2008). We therefore hypothesised an increase in marital breakdown in families after age 3 during primary school years, when ADHD behaviours become problematic. In MCS, there was no discernible increase in percentage of lone parent families in the ADHD group after the age of 3. There was an association between lone parenthood and childhood ADHD, but this was true at 9 months and at 3 years, before ADHD behaviours typically become problematic.

Checking for clinical labelling bias

Logistic regression reported in Table 1 was repeated, but adjusted for parent and teacher-rated symptoms of ADHD. The remaining association between ADHD and SES is reported in Table 2. No association of clinical diagnosis with social disadvantage remained independently of parent–teacher-rated symptom level: adjustment accounted for every significant association between ADHD diagnosis with measures of SES. Results suggest that socioeconomic labelling practices do not differ substantially between doctor’s diagnosis of ADHD and parent–teacher ratings of symptoms of ADHD.

Checking for mediation

Both smoking during pregnancy and family conflict/distant parenting were independently associated with all the measures of SES. Where more conflict and less closeness was reported between parent and child, families were more likely to experience social or economic disadvantage. Distant parenting/family conflict was also associated with having a child with ADHD, OR = 1.11, 95% CI (1.08–1.13), p < 0.001; even after adjustment for measures of socioeconomic disadvantage OR = 1.09, 95% CI (1.05–1.21), p < 0.001.

In MCS, 5239 mothers reduced their tobacco use during pregnancy with 2327 mothers giving up smoking, and 1664 continuing to smoke: these were more likely to be from low SES backgrounds. Mothers were more likely to have a child with ADHD if they smoked during pregnancy: OR = 2.26, 95% CI (1.54–3.31) p < 0.001. Smoking in pregnancy was still independently associated with ADHD after adjusting for salient measures of SES, although its effect was weaker, OR = 1.53, 95% CI (1.03–2.29) p = 0.036.

Table 2 The association of indicators of socioeconomic disadvantage with ADHD adjusted for parent and teacher SDQ hyperactivity & impact subscales.

| Sociodemographic factors | OR (95% CI) adjusted | p    |
|---------------------------|-----------------------|------|
| Birth weight (kg)         | 0.96 (0.59, 1.57)     | 0.891|
| Maternal (years)          | 0.99 (0.95, 1.03)     | 0.721|
| Family income (£1000)     | 0.92 (0.26, 3.19)     | 0.892|
| Family size: overall      |                       |      |
| Only child                | Referent              |      |
| 1 sibling                 | 1.04 (0.44, 2.46)     | 0.924|
| 2 siblings                | 1.36 (0.64, 2.87)     | 0.409|
| More than 2 siblings      | 0.85 (0.32, 2.27)     | 0.752|
| Maternal education: overall |                     |      |
| No qualifications         | Referent              |      |
| School level              | 0.69 (0.35, 1.34)     | 0.275|
| Degree or higher          | 1.17 (0.55, 2.46)     | 0.680|
| Poverty                   |                       |      |
| Above poverty line – sweep 4 |                     |      |
| Below poverty line        | 1.07 (0.62, 1.86)     | 0.803|
| Family type: – sweep 4    |                       |      |
| Dual parent               | Referent              |      |
| Single parent family      | 1.11 (0.61, 2.03)     | 0.734|
| Housing tenure – sweep 4 : overall |             |      |
| Social housing,%          | Referent              |      |
| Rent private,%            | 1.12 (0.44, 2.86)     | 0.806|
| Home owner,%              | 0.94 (0.55, 1.62)     | 0.829|
| Index of SES: – sweep 1   | 1.03 (0.86, 1.24)     | 0.648|
analysed labour supply (i.e. number of days taken reverse causality hypothesis. Kvist et al. (2013) 2004). This study found no evidence for such a sequences for families (Doshi et al., 2012; Litt, lised ADHD as a disorder with socioeconomic con- 
mental health problems (Reiss, 2013).

Other studies (Akinbami et al., 2011; D opfner et al., € opfner et al., 2004). To our knowledge, the only systematic review that has touched on this subject was focused 
findings that concurs with results from a wide range of other studies (Akinbami et al., 2011; Döpfner et al., 2008; Ford et al., 2007; Froehlich et al., 2007; Pastor & Rueben, 2008; Sciberras et al., 2011; St Sauver et al., 2004). To our knowledge, the only systematic review that has touched on this subject was focused on treatment of ADHD and not symptoms or diagnosis of ADHD per se (Charach et al., 2011). A recent systematic review of child mental health more generally found socioeconomically disadvantaged individuals were two to three times more likely to develop mental health problems (Reiss, 2013).

Models from health economics have conceptualised ADHD as a disorder with socioeconomic consequences for families (Doshi et al., 2012; Litt, 2004). This study found no evidence for such a reverse causality hypothesis. Kvist et al. (2013) analysed labour supply (i.e. number of days taken

Figure 3 Causal pathway with effect sizes for mediated and nonmediated pathways from SES to ADHD: (i) no mediator; (ii) two mediators

Discussion
This study detected a higher prevalence of ADHD among socioeconomically disadvantaged groups, a finding that concurs with results from a wide range of other studies (Akinbami et al., 2011; Döpfner et al., 2008; Ford et al., 2007; Froehlich et al., 2007; Pastor & Rueben, 2008; Sciberras et al., 2011; St Sauver et al., 2004). To our knowledge, the only systematic review that has touched on this subject was focused on treatment of ADHD and not symptoms or diagnosis of ADHD per se (Charach et al., 2011). A recent systematic review of child mental health more generally found socioeconomically disadvantaged individuals were two to three times more likely to develop mental health problems (Reiss, 2013).

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**Observed coefficients**

| Coefficient | Value | 95% CI |
|-------------|-------|--------|
| a           | 0.181 | (0.091, 0.274)* |
| b1          | 0.029 | (-0.009, 0.069) |
| b2          | 0.045 | (0.032, 0.056)* |
| c           | 0.108 | (-0.003, 0.205)* |

* CIs from observed coefficient do not cross zero, providing evidence for pathway.
design was that we were not able to account for genetic predisposition and its potential confounding effect. It was not possible to weight the data in analysis of mediation; however, unweighted regression models are often robust in large datasets (see Wolke et al., 2009). Although the analysis explored parental attachment/family conflict as a simple mediating factor, parenting itself may be influenced by shared genetic predisposition, as well as the effect of having a hyperactive child, hence the bidirectional nature of the arrow in Figure 1, pathway 2. There is evidence to suggest treatment with Methylphenidate improves family functioning, for example (Barkley, Karlsson, Pollard, & Murphy, 1985). The influence and character of parenting is likely more complex than acting as a simple mediating factor.

Overall, results provided no evidence for the reverse causation model, or of labelling bias: instead, findings suggest that mediators linked to SES or genetic confounds may provide the most useful framework to explain why ADHD occurs more often in socioeconomically disadvantaged groups (Pathways 1–4, Figure 1). The aetiology of ADHD is likely to be a complex interplay of genetic and environmental factors, some linked to socioeconomic disadvantage. Bronfenbrenner (1979) posits a contextual systems model of child development that considers proximal and distal factors that affect how individuals with innate differences react to given environments. As the association between childhood ADHD and socioeconomic disadvantage appears increas-ingly robust, it becomes important to search for possible explanations for the link. Meta-analysis across many studies is required to substantiate the extent of the association across cultures. Our findings need to be replicated in other datasets, at other developmental stages, and indicate the need for research to examine further potential pathways, especially controlling for genetic predisposition.

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Key points
- Childhood attention deficit hyperactivity disorder (ADHD) and its behavioural symptoms have often been associated with socioeconomic disadvantage.
- In a 2008 sample representative of the United Kingdom, ADHD was associated with a range of indicators of social and economic disadvantage.
- The study provided no evidence to suggest childhood ADHD was a causal factor of socioeconomic disadvantage and no evidence of labelling bias.
- Parent attachment/family conflict apparently mediated the relationship between ADHD and SES.

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