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Abstract	The UK prevalence of parent-reported autism spectrum disorder (ASD) and attention deficit/hyperactivity disorder (ADHD) were estimated from the Millennium Cohort Study. Case definition was if a doctor or health care professional had ever told parents that their child had ASD and/or ADHD. Data were collected in 2008/2009 for 14,043 children. 1.7 % of children were reported as having ASD (95 % CI 1.4–2.0) at mean age 7.2 years (SD = 0.2; range = 6.3–8.2). 1.4 % reportedly had ADHD (95 % CI 1.2–1.7), and 0.3 % had both ASD and ADHD (95 % CI 0.2–0.5). After adjusting for socio-economic disadvantage, only male sex ($p < 0.001$ for both conditions) and cognitive ability, $p = 0.004$ (ASD); $p = 0.01$ (ADHD) remained strongly associated. The observed prevalence of parent-reported ASD is high compared to earlier UK and US estimates. Parent-reported ADHD is low compared to US estimates using the same measure.

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ORIGINAL PAPER

Prevalence of Parent-Reported ASD and ADHD in the UK: Findings from the Millennium Cohort Study

Ginny Russell · Lauren R. Rodgers · Obioha C. Ukoumunne · Tamsin Ford

Abstract The UK prevalence of parent-reported autism spectrum disorder (ASD) and attention deficit/hyperactivity disorder (ADHD) were estimated from the Millennium Cohort Study. Case definition was if a doctor or health care professional had ever told parents that their child had ASD and/or ADHD. Data were collected in 2008/2009 for 14,043 children. 1.7 % of children were reported as having ASD (95 % CI 1.4–2.0) at mean age 7.2 years (SD = 0.2; range = 6.3–8.2). 1.4 % reportedly had ADHD (95 % CI 1.2–1.7), and 0.3 % had both ASD and ADHD (95 % CI 0.2–0.5). After adjusting for socio-economic disadvantage, only male sex ($p < 0.001$ for both conditions) and cognitive ability, $p = 0.004$ (ASD); $p = 0.01$ (ADHD) remained strongly associated. The observed prevalence of parent-reported ASD is high compared to earlier UK and US estimates. Parent-reported ADHD is low compared to US estimates using the same measure.

Keywords Attention deficit hyperactivity disorder · Autism · Prevalence · Co-morbidity · Pervasive developmental disorder · Autism spectrum disorder

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Introduction

The last 20 years have seen steady increases in the estimated prevalence of both autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) in childhood (Boyle et al. 2011). Despite exclusion clauses in diagnostic criteria for ASD relating to ADHD (World Health Organization 1993; American Psychiatric Association 2000) considerable symptom overlap between these conditions has been reported (Simonoff et al. 2008; Reiersen and Todd 2008).

Estimates of the prevalence of both conditions worldwide vary widely (Newschaffer et al. 2007; Brown et al. 2001; Polanczyk et al. 2007). Knowledge of the number of children identified with these disorders is crucial for planning and commissioning services and studying the process of identification in clinical practice. Nevertheless, there is no UK public health record that gives a definitive number of children with a diagnosis of either condition. Researchers have therefore estimated prevalence in the community in a variety of ways.

Screening instruments combined with assessments and parent-reported clinical diagnosis resulted in an estimated ASD prevalence of 1.57 % for children aged 5–9 in 2004 in the UK in a sample from primary schools (Baron-Cohen et al. 2009). An earlier UK cohort study screened the 'at-risk of ASD' population with parent and teacher assessment instruments, producing a estimate of 1.16 % of children having an ASD (Baird et al. 2006). A population-based sample estimated the UK prevalence of both ASD (0.9 % in 2004) and ADHD (approximately 1.5 %) using both semi-structured interviews and an instrument designed to identify DSM diagnoses in 5–15 years olds (Green et al. 2003). Polanczyk et al. (2007) systematic review of the worldwide prevalence of ADHD found recorded rates ranging from 1 to

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18 %. This wide variation is likely to be in part due to a lack of standardisation in case ascertainment.

Clinical practice varies widely between cultures and even within countries (e.g. Reid et al. 2002). Several studies have addressed the issue of cross-cultural differences in labelling, for example, in South Korea, some researchers have argued under-diagnosis of ASD is due to strong stigma attached to the disorder (Grinker et al. 2012). Others have argued that cultural, social and developmental context elicit differences in impact and expression of symptoms and behaviours (Caron et al. 2012; Singh 2011; Norbury and Sparks 2013). Objective measures to diagnose that reach across cultures are therefore hard to establish. Taylor and Sandberg (1984) questioned why measured rates of ADHD in the UK were lower than the US, sparking further debate as to whether this really was the case (Faraone et al. 2003). Malacrida (2004) discusses the reluctance of European clinicians and parents to utilise the ADHD label and administer pharmaceutical treatment (usually methylphenidate) compared to US counterparts. Polanczyk et al. (2007) however, found no differences between European and US rates of ADHD in their systematic review. In the US, 6.3 % of all children aged 5–9 were reported by parents to have an ADHD diagnosis in 2008–2010 (National Center for Health Statistics 2012).

Both diagnoses have been associated with socio-economic factors. In the US, studies based on the National Health Interview Survey data, and others, show that ASD prevalence is lower among groups of lower socio-economic status (Fountain et al. 2011; Kogan et al. 2009). By contrast, higher rates of ADHD have been observed for socially disadvantaged groups (Pastor and Rueben 2008; Akinbami et al. 2011; Bøe et al. 2012; Hjern et al. 2010). A range of other factors, including child's sex, maternal depression, older motherhood, intellectual disability, and ethnicity have also been associated with both conditions (Akinbami et al. 2011; Banerjee et al. 2007; Kogan et al. 2009; Lesesne et al. 2003; Pastor and Rueben 2008; Russell et al. 2011; Sandin et al. 2012; Scahill et al. 1999). Birth complications and prenatal risk factors have been linked to both conditions (Gardener et al. 2009; Linnet et al. 2003). It is important to establish whether some groups of children are more likely to be identified, as differing contexts may lead to children missing out on health services, or to over-identification.

The aims of our study were to estimate the prevalence of parent-reported ASD and ADHD in the UK and examine association between recognition of these disorders and socio-demographic, child-based and contextual factors. The prevalence of both conditions was estimated using data from the Millennium Cohort Study (MCS), a large UK population-based birth cohort study. ASD and ADHD status were measured over a 13 months period between 2008 and 2009 when the children were around 7 years old from parent-report of whether either condition was identified by a doctor or other health professional. The same measure was used by the US National Health Interview Survey Sample Child questionnaire to identify developmental disabilities in the United States (for example, Kogan et al. 2009; Boyle et al. 2011; Pastor and Rueben 2008). Parents reported on identified ASD and ADHD in their children over a 13 months period between 2008 and 2009.

Methods

The MCS is a UK-representative birth cohort study using a disproportionate stratified cluster sampling design. Sampling of electoral wards (the clusters) was stratified by UK country (England, Scotland, Wales and Northern Ireland), and further stratified by ethnic group composition (whether at least 30 % of the population fell into the categories "Black" or "Asian") and level of Child Poverty in England, and by level of social disadvantage in Scotland, Wales and Northern Ireland (Hansen and Joshi 2010). There was further implicit stratification by region (within country), and by electoral ward size. Details of the sampling design are documented in detail elsewhere (Plewis 2007). Children born between 1st September 2000 and 11th January 2002 and listed on the Child Benefit Records (which had near universal take up) were eligible for the study. Data were first collected when children were 9 months old (1st wave), including hospital birth records and socio-demographic and family circumstances. Subsequently, further data were recorded concerning the children's health and development when the children were 3 years old (2nd wave), 5 years old (3rd wave) and 7 years old (4th wave). Within the total MCS cohort of 15, 918 % responded to the questions about ASD Consistent with other studies using these data (Totsika et al. 2011), families with twins or triplets where all the siblings participated were excluded (252 twins, 11 triplets) as outcomes would be expected to be correlated within families.

Outcome Measures

The outcome measure of ASD or ADHD status was based on responses to the MCS question duplicated from the US National Health Interview Survey questionnaire reported in previous studies (Akinbami et al. 2011; Boyle et al. 2011; Kogan et al. 2009; Pastor and Rueben 2008). The main carer was asked if a child had ADHD or ASD identified by doctor or health professional. In 96.7 % of cases the carer was the child's mother, who in over 99 % of cases was resident at home with the child all of the time. This measure was used in a face to face interview in each child's

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home by trained interviewers, with the wording of the question read out verbatim:

- Has a doctor or health professional ever told you that (sample child) attention deficit hyperactivity disorder (ADHD)/Has a doctor or health professional ever told you that (sample child) had Autism, Asperger's syndrome or autistic spectrum disorder?

Data on ASD and ADHD status were collected at both waves 3 and 4. Wave 4 ASD/ADHD status data, (mean age of child 7 years old), were analysed in this study. A positive or negative response to the above question was taken as the case definition for diagnosis of ASD or ADHD. Data were coded as missing where a response of 'don't know' or 'not applicable' was recorded.

Potential Predictors

Several variables that had previously been found to be associated with ASD or ADHD were available. Child-based measures included sex, age and cognitive ability of children, which was recorded at age three using a series of tests administered by trained researchers during individual visits to all children's homes. The cognitive test used was the Bracken School Readiness Assessment (Bracken 1999). The test comprised six subtests that assess a child's ability to identify colours, letters, numbers, shapes and to describe and compare objects (e.g., by size). These assessments were individually administered in computer-assisted interviews. The test has been used as an intellectual screening instrument (Laughlin 1995). Other child-based factors were derived from linked UK Birth Registration and Maternity Hospital Episode Data, including birth weight, gestation length (i.e. before 280 days if premature birth), type of delivery, and length of labour. Mothers responding to the 9 months interview were asked to give written consent to birth registration and hospital maternity records being added to the survey. This interview also recorded tobacco use during pregnancy.

Family-based background factors including the age of the mother at childbirth, the ethnicity of the family into which the child had been born and family size were reported at waves 1–4. A measure of maternal mental health was taken from mothers' reports of whether they had ever been diagnosed with depression or anxiety by wave 4. Indicators of family socio-economic status (SES) were family income (adjusted for the number of children per family), housing tenure, number of full time carers at child's home (single parent or couple), and mother's highest educational qualification. Families were classed as living in poverty if their income was equal to or less than 60 % of the median household income for the UK population at wave 4.

Statistical Analysis

Demographic characteristics for the study sample overall, by ASD status and by ADHD status, were reported. Logistic regression was used to examine the association between ASD/ADHD status and the following potential predictors: child's sex, cognitive ability at age 3, birth weight, and exact age of child in months, pre and perinatal factors (child characteristics); maternal education, maternal age at childbirth, ethnicity, equivalised family income, family size, family structure, housing tenure, poverty level and whether mothers had been diagnosed with depression (family characteristics).

In the logistic regression models continuous predictors were rescaled (divided by 2 standard deviations), so that odds ratios (OR) indicate the relative increase in odds of being identified with the condition, corresponding to a 2 standard deviation increase in the predictor. This transformation enables comparison of strength of association across continuous and binary predictors (Gelman 2008). Unadjusted logistic regression models were fitted in which just one predictor at a time was included. Multivariable (adjusted) logistic regression models were then fitted in which predictors significant at the 10 % level in the unadjusted analyses were included as covariates.

Estimates of the prevalence of ASD and ADHD and the logistic regression analyses were weighted to take account of the disproportionate stratified sample of electoral wards and attrition/non-response by the 4th wave when the study outcomes were measured, making the sample representative of the UK population (Plewis 2007). Standard errors in the logistic regression were calculated using first-order Taylor linearisation to take account of the correlation of responses between children within electoral ward clusters. All analyses were performed using Stata 12 software. The complete case analyses reported here include only participants with data for both the outcome and all predictors in the model. The numbers of observations analysed exceeded 13,000 for all but two predictors (from a possible 13,586 responses to the question about ASD and 13,574 responding to ADHD status); the exceptions were maternal depression (n = 8,443) and ethnicity (n = 11,883).

Results

For 96.7 % of those participating at wave 4, the main respondent on the outcome measure of ASD or ADHD was the child's mother. At the birth of the child, mothers had a mean age of 28 years (range 13–48 years). The mean age of children when outcome measures were taken was 7.2 years (SD = 0.2; range 6.3–8.2). Table 1 illustrates the demographic profile of the sample.

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Table 1 Descriptive statistics: child- and family-based background factors for children by ASD and ADHD status

Characteristic	ASD (N = 86–209)	No ASD (N = 8,363–13,377)	ADHD (N = 59–173)	No ADHD (N = 8,384–13,401)	Comorbid ASD and ADHD (N = 8–44)	No diagnosis ASD or ADHD (N = 8,306–13,231)
Child characteristics						
Male (%)	83.9	50.2	82.2	50.3	93.0	49.9
Birth weight in kg, mean (SD)	3.4 (0.6)	3.4 (0.6)	3.3 (0.6)	3.4 (0.6)	3.4 (0.5)	3.4 (0.6)
Age in years at wave 4, mean (SD)	7.2 (0.3)	7.2 (0.2)	7.2 (0.2)	7.2 (0.2)	7.2 (0.3)	7.2 (0.2)
Cognitive ability—wave 2, mean (SD)	43.8 (34.6)	58.2 (30.3)	44.1 (30.4)	58.3 (30.4)	40.2 (32.9)	58.4 (30.3)
Number of cigarettes smoked in pregnancy, mean (SD)	1.3 (3.3)	1.0 (3.4)	1.9 (4.0)	1.0 (3.4)	1.4 (3.0)	1.0 (3.4)
Length of labour in hours, mean (SD)	8.2 (8.8)	9.2 (11.1)	10.2 (14.0)	9.1 (11.0)	7.7 (8.4)	9.1 (11.0)
Days gestation, mean (SD) 280 = due date	274.9 (17.1)	277.6 (13.4)	274.5 (17.8)	277.6 (13.4)	276.8 (14.0)	277.6 (13.3)
Delivery type (%)						
No problems	68.4	69.0	68.5	69.0	80.0	69.0
Forceps/breach/vacuum	8.7	9.7	7.3	9.7	2.5	9.7
Caesarean	23	21.3	24.2	21.3	17.5	21.3
Family characteristics						
White British (%)	92.4	86.5	90.9	86.5	94.6	86.5
Family size—wave 4						
Only child (%)	17.7	12.9	16.8	12.9	15.9	12.8
1 sibling (%)	43.5	45.2	39.9	45.3	45.5	45.3
2 siblings (%)	25.4	27.1	26.6	27	22.7	27.1
More than 2 siblings (%)	13.4	14.8	16.8	14.8	15.9	14.8
Maternal age at childbirth, mean (SD)	27.9 (5.9)	28.7 (5.8)	26.2 (5.8)	28.8 (5.8)	26.2 (5.4)	28.8 (5.8)
Maternal education—wave 1						
No qualifications (%)	17.1	16.6	25.4	16.5	20.9	16.5
School level (%)	62.3	56.3	60.4	56.3	62.8	56.3
Degree or higher (%)	20.6	27.1	14.2	27.2	16.3	27.2
Mother depression/anxiety—wave 4 (%)	10.5	6.6	8.5	6.6	0	6.6
Family income in £—wave 4, mean (SD)	351.2 (209.2)	382.2 (228.0)	312.9 (179.9)	382.8 (228.1)	324.2 (172.2)	383.1 (228.2)
Below poverty line—wave 4 (%)	35.4	30	42.8	29.9	40.9	29.8
Single parent family—wave 4 (%)	34.9	20.9	37	20.9	40.9	20.7
Housing tenure—wave 4						
Social housing (%)	31.9	23.2	40.9	23.1	36.4	23
Rent private (%)	13.2	8.8	15.2	8.8	15.9	8.8
Home owner (%)	54.9	68	43.9	68.1	47.7	68.3

[1] N range is given as not all children have recorded data for every characteristic. Where data were missing they were excluded from the analysis

After excluding twins and triplets, at wave 4, there were 13,586 responses concerning ASD status and ADHD status of children. Of these children, 209 were reported to have ASD and 173 to have ADHD. Forty-four children reportedly had both ASD and ADHD. The prevalence for ASD was 1.7 % (95 % CI 1.4–2.0) overall; 2.5 % for boys and 0.5 % for girls, giving a male to female ratio of approximately 5–1 for ASD. Prevalence of ADHD was 1.4 % (95 % CI 1.2–1.7) overall; 2.2 % of boys and 0.5 % of girls, giving a male to female ratio of approximately 4–1. The proportion of children with both conditions was 0.3 (95 % CI 0.2–0.5). 19.9 % of the children with ASD also had ADHD (95 % CI 13.2–26.6) while 24.1 % of the children with ADHD had ASD (95 % CI 18.9–32.0).

At wave 3 children were approximately 5 years of age (range 4.9–5.5 years). Not surprisingly, more children had been identified with both conditions by age seven. The prevalence of ASD for 5 years olds was 0.9 and 0.9 % for ADHD. Drop-out from wave 3 to wave 4 was slightly greater for those with ASD and/or ADHD than for other children. Nineteen percent of those with ADHD at wave 3 were missing at wave 4 (26/134), compared to 13 % (1,932/14815) missing from the rest of the sample, while 20 % (26/131) of those with ASD at wave 3 were missing compared to 13 % (1,933/14,826) of non-respondents without the diagnosis.

Table 2 reports the odds ratios (OR) of having ASD for the unadjusted and adjusted analyses. For factors significant

Table 2 Logistic regression of ASD status on background factors

Predictors	Unadjusted[a]		Adjusted[b]	
	OR (95 % CI)	*p*	OR (95 % CI)	*p*
Child characteristics				
Male	5.02 (3.19–7.90)	<0.001	4.94 (2.58–9.44)	<0.001
Birth weight	0.94 (0.60–1.47)	0.78		
Age at wave 4	0.91 (0.64–1.29)	0.58		
Cognitive ability—wave 2	0.41 (0.26–0.63)	<0.001	0.49 (0.30–0.79)	0.003
Number of cigarettes	1.18 (0.98–1.41)	0.08	0.99 (0.78–1.27)	0.95
Length of labour	0.88 (0.64–1.21)	0.42		
Days gestation	0.64 (0.45–0.92)	0.01	0.69 (0.44–1.09)	0.12
Delivery %		0.91		
No problems at birth	Reference			
Forceps/breach/vacuum delivery	0.91 (0.43–1.97)			
Caesarean	1.07 (0.72–1.59)			
Family characteristics				
White British	0.82 (0.37–1.80)	0.62		
Family size—wave 4		0.46		
Only child	Reference			
1 sibling	0.70 (0.41–1.19)			
2 siblings	0.70 (0.41–1.20)			
More than 2 siblings	0.62 (0.34–1.15)			
Maternal age at childbirth	0.80 (0.57–1.23)	0.20		
Maternal education—wave 1		0.12		
No qualifications	Reference			
School level	1.12 (0.72–1.72)			
Degree or higher	0.70 (0.39–1.24)			
Maternal depression/anxiety diagnosis—wave 4	1.85 (0.86–3.94)	0.11		
Family income—wave 4	0.68 (0.48–0.95)	0.02	1.42 (0.89–2.28)	0.14
Below poverty line—wave 4	1.27 (0.90–1.79)	0.17		
Single parent family—wave 4	1.87 (1.30–2.68)	0.001	1.11 (0.62–2.01)	0.72
Housing tenure—wave 4		0.001		0.03
Social housing (%)	Reference		Reference	
Rent private (%)	0.93 (0.55–1.60)		0.82 (0.38–1.75)	
Home owner (%)	0.51 (0.35–0.74)		0.47 (0.27–0.81)	

Odds ratios (ORs) shown for a 2 standard deviation increase in continuous predictors

[a] Sample size ranges from 8,449 to 13,586 in unadjusted analyses

[b] Sample size is 10, 230 in adjusted analysis

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at the 10 % level in the unadjusted analysis, the right hand column of Table 2 shows adjusted odds ratios which take interdependencies between predictors into account. In the unadjusted analyses there was strong evidence that boys and those with lower scores on the school readiness assessment (lower cognitive ability) at 3 years were more likely to have an ASD. Increasing tobacco use in pregnancy and a more premature birth were also associated with ASD. Birth weight, length of labour, method of delivery and the child's exact age when the wave 4 data were recorded did not appear to be associated with the odds of having ASD.

Several measures of socio-economic disadvantage in the children's family background were associated with ASD. Children from families with lower income were more likely to have ASD. Children living in social housing and those from single parent families were also more likely to have ASD (Table 2). There was little evidence of association between the other family-based factors that were examined and ASD.

In the adjusted model, lower cognitive ability and male sex were the factors most strongly associated with ASD, together with one measure of socio-economic status: social housing. Families living in social housing were still around twice as likely to have a child with ASD compared to families that own their homes.

Table 3 reports the logistic regression for the children with ADHD. In the unadjusted analysis, the same child-based factors that were significantly associated with ASD

Table 3 Logistic regression of ADHD status on background factors

Predictors[a]	Unadjusted[b]		Adjusted[c]	
	OR (95 % CI)	*p*	OR (95 % CI)	*p*
Child characteristics				
Male	4.26 (2.77–6.56)	<0.001	4.56 (2.55–8.14)	<0.001
Birth weight	0.84 (0.57–1.25)	0.39		
Age at wave 4	1.16 (0.86–1.57)	0.32		
Cognitive ability—wave 2	0.40 (0.26–0.62)	<0.001	0.54 (0.34–0.88)	0.01
Number of cigarettes smoked prenatal	1.36 (1.19–1.56)	<0.001	1.10 (0.90–1.36)	0.35
Length of labour	1.36 (1.01–1.83)	0.04	1.35 (1.00–1.81)	0.05
Days gestation	0.65 (0.48–0.88)	0.006	0.67 (0.48–0.93)	0.02
Delivery %		0.38		
No problems at birth	Reference			
Forceps/breach/vacuum	0.69 (0.37–1.29)			
Caesarean	1.14 (0.78–1.66)			
Family characteristics				
White British	1.46 (0.74–2.89)	0.28		
Family size—wave 4		0.13		
Only child	Reference			
1 sibling	0.56 (0.34–0.91)			
2 siblings	0.68 (0.40–1.14)			
More than 2 siblings	0.78 (0.45–1.34)			
Maternal age at childbirth	0.46 (0.33–0.65)	<0.001	0.63 (0.38–1.04)	0.07
Maternal education—wave 1		<0.001		0.91
No qualifications	Reference		Reference	
School level	0.62 (0.41–0.94)		0.97 (0.50–1.90)	
Degree or higher	0.32 (0.19–0.56)		0.86 (0.37–2.01)	
Maternal depression/anxiety—wave 4	1.03 (0.39–2.72)	0.95		
Family income—wave 4	0.52 (0.35–0.77)	0.001	1.21 (0.72–2.04)	0.47
Below poverty line—wave 4[a]	1.64 (1.12–2.39)	0.01		
Single parent family—wave 4	2.06 (1.41–3.00)	<0.001	1.29 (0.72–2.29)	0.39
Housing tenure—wave 4		<0.001		0.42
Social housing (%)	Reference		Reference	
Rent private (%)	0.81 (0.46–1.42)		1.15 (0.50–2.63)	
Home owner (%)	0.37 (0.26–0.54)		0.73 (0.42–1.28)	

Odds ratios (ORs) shown for a 2 standard deviation increase in continuous predictors

[a] Poverty was not included in the adjusted model as it is derived from the family income variable which was also significant at the 10 % level in the unadjusted analysis

[b] Sample size ranges from 8,443 to 13,574 in unadjusted analyses

[c] Sample size is 9,808 in adjusted analysis

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Table 4 Logistic regression of comorbid status on background factors

Predictors	Unadjusted[a]		Adjusted[b]	
	OR (95 % CI)	*p*	OR (95 % CI)	*p*
Child characteristics				
Male	18.77 (4.58–76.88)	<0.001	23.54 (3.49–158.60)	0.001
Birth weight	0.93 (0.48–1.77)	0.82		
Age at wave 4	1.09 (0.57–2.10)	0.79		
Cognitive ability—wave 2	0.32 (0.13–0.78)	0.01	0.39 (0.18–0.86)	0.02
Number of cigarettes smoked during pregnancy	1.27 (0.95–1.70)	0.11		
Length of labour	0.78 (0.41–1.50)	0.48		
Days gestation	0.79 (0.40–1.58)	0.51		
Delivery %		0.35		
No problems	Reference			
Forceps/breach/vacuum	0.23 (0.03–1.67)			
Caesarean	0.98 (0.42–2.27)			
Family characteristics				
White British	1.93 (0.46–8.12)	0.37		
Family size—wave 4		0.63		
Only child	Reference			
1 sibling	0.76 (0.28–2.04)			
2 siblings	0.48 (0.15–1.47)			
More than 2 siblings	0.76 (0.25–2.37)			
Maternal age at childbirth	0.61 (0.34–1.09)	0.10		
Maternal education—wave 1		0.39		
No qualifications	Reference			
School level	1.02 (0.43–2.39)			
Degree or higher	0.54 (0.18–1.62)			
Maternal depression/anxiety—wave 4	NA[c]			
Family income—wave 4	0.51 (0.24–1.07)	0.08	1.25 (0.60–2.60)	0.54
Below poverty line—wave 4[a]	1.86 (0.88–3.94)	0.10		
Single parent family—wave 4	2.88 (1.45–5.70)	0.003	1.83 (0.62–5.36)	0.27
Housing tenure—wave 4		0.006		0.35
Social housing (%)	Reference			
Rent private (%)	1.10 (0.35–3.44)		1.52 (0.39–5.98)	
Home owner (%)	0.43 (0.20–0.93)		0.61 (0.27–1.39)	

Odds ratios (ORs) shown for a 2 standard deviation increase in continuous predictors

[a] Sample size ranges from 7,769 to 13,275 in unadjusted analyses

[b] Sample size is 10,114 in adjusted analysis

[c] NA (not applicable): no mothers of children with both ASD and ADHD reported depression or anxiety

were also associated with ADHD; lower cognitive ability and male sex. In addition, three pre- and perinatal factors were associated with ADHD, prematurity, smoking during pregnancy and longer labour. There was little evidence of associations between ADHD status and the exact age of child at the fourth MCS wave, or their birth weight. Several family-based socio-economic measures of disadvantage were strongly linked to ADHD: lower income, lower maternal education and poverty. Mothers who were younger when the study child was born, families living in social housing and single parent families had greater odds of having a child with identified ADHD. There was, however, no significant association between ADHD and ethnicity, maternal depression or family size.

In the adjusted analysis sex and cognitive ability were most strongly associated with ADHD. Boys were still over four times more likely to have ADHD than girls (OR = 4.56, 95 % CI 2.55–8.14). Each drop of two standard deviations in the Bracken school readiness assessment was associated with an almost two-fold increase in the odds of having ADHD. In the adjusted analysis, length of gestation: our proxy for prematurity, and longer labour were still related to the ADHD outcome, but not as strongly as cognitive ability and sex.

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Finally, Table 4 reports results for the group of children who were reported as having both ASD and ADHD. In these analyses, only male sex and cognitive ability increased odds of having co-morbid ASD and ADHD after adjustment for interdependencies. Caution is needed interpreting these findings due to low numbers in the comorbid category (Table 1).

Discussion

The estimated prevalence of ASD of 1.7 % is high compared to other UK and US estimates which have ranged from 0.9 to 1.6 % in recent literature (Baird et al. 2006; Baron-Cohen et al. 2009; Kogan et al. 2009; Zaroff and Uhm 2011). The finding suggests an increasing trend in the UK to apply the ASD label which may be due to a combination of greater awareness, successive diagnosis of younger children, broadening criteria (Fombonne 2001, 2009) and/or lessening of social stigma associated with the label (Gray 2002). One debate surrounding the rising prevalence of developmental disorders concerns whether rises reflect real increases in frequency and severity of symptoms, or whether they are entirely an artefact of changing diagnostic criteria and increased awareness. Some people affected by these conditions, and some researchers, believe that shifts in diagnostic categorisation do not entirely explain rising prevalence. An underlying concern among these people is that environmental influences may be partially to blame (Russell and Kelly 2011). It is beyond the scope of this study to address what the triggers for increasing prevalence may be.

In contrast, the estimated prevalence of ADHD in the UK at 1.5 % is very similar to previous estimates for ADHD and hyperkinetic disorder in the UK based on research diagnosis (Ford et al. 2003; Green et al. 2005). Such estimates are low compared to the European ADHD prevalence of 3–5 % given in the meta-analysis of Polanczyk et al. (2007). However, the meta-analysis did not include UK estimates. In addition, in the current study, a substantial proportion of children with ADHD may not have been diagnosed by age seven (Kieling et al. 2010): therefore we would expect around half the population that eventually receive an ADHD diagnosis to be undetected in the study age range of 6–8. There have been debates about whether the prevalence of ADHD is lower in the UK than the US (Charach et al. 2011; Faraone et al. 2003; Taylor and Sandberg 1984). Our findings suggest the ADHD diagnosis is not as often used by UK doctors and/or health professionals as it is in the USA (Boyle et al. 2011; Pastor and Rueben 2008; Akinbami et al. 2011); whereas the autism spectrum as a diagnosis is on the ascent in the UK. The nearest comparator in the US for ADHD is in 5–9 year-olds from 2008 to 2010 using the same parent-report measure. This gives a prevalence estimate for the USA of 6.3 % with ADHD (National Center of Health Statistics 2012, Table 46). The current study uses the same parent-report measure in 6–8 years-olds in 2008–2009 and derives a UK estimate of 1.4 % for ADHD. The comparatively sparse use of ADHD label in the UK may be due to lower numbers of children with symptoms in the UK, or more likely, apprehension regarding ADHD diagnosis and/or impact of diagnosis on children and their families, ~~or~~ persistent concerns regarding its treatment with stimulant drugs (Malacrida 2004). The ~~current~~ diagnostic classifications suggest ~~the~~ diagnosis of ASD rules out a diagnosis of ADHD, so ~~that~~ children with hyperactive behaviour in combination with social difficulties may be more likely to be diagnosed as having ASD in the UK and ADHD in the USA ~~(APA 2000; WHO 1993)~~.

However, our findings suggest that ASD and ADHD labels are used together in a small but noteworthy proportion of the clinical child population, despite the exclusionary criteria of diagnostic criteria ~~(APA 2000; WHO 1993)~~. In doing so, clinical practice is consistent with other studies that show ASD and ADHD often co-exist (Simonoff et al. 2008; Reiersen and Todd 2008). ~~Indeed, recent debates have addressed whether the two conditions should be considered as different manifestations of one overarching disorder (van der Meer et al. 2012; Hattori et al. 2006). These and other studies lend weight to proposed revisions to DSM-5 and ICD 11 that will see exclusivity criteria between the conditions removed.~~

The high estimates for ASD may reflect measurement error. Whether a child 'had ever been said to have an ASD by doctor or health professional' may have been over-inclusive. This was the major limitation to the study. Parents may have inferred a positive answer in cases where ASD or ADHD was suggested by a ~~school psychologist or~~ health worker but not confirmed by further assessment. The slightly increased drop-out in the ASD and ADHD groups between waves suggests that our figures for ASD and ADHD may be slightly underestimated at wave 4. The effect of drop-out should be the same for reports of ADHD and ASD; so they do not explain low estimates of ADHD relative to ASD. US studies using the NHIS question to parents have shown discrepancies between 'current' and 'previous' diagnoses of autism (Kogan et al. 2009), suggesting a current diagnosis may become invalid as children mature. Children may no longer meet diagnostic criteria after symptomatic behaviours at preschool or kindergarten (Fein et al. 2013; Turner and Stone 2007; Russell et al. 2012); early misdiagnosis may be partially accountable for ASD over-identification.

A major strength of the current study was the ability to compare parent-reported ASD and ADHD across social

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strata. Male sex and lower cognitive ability were the strongest predictors of both conditions and there was a tendency for socially disadvantaged groups to have higher proportions with ADHD, consistent with previous findings (Akinbami et al. 2011; Banerjee et al. 2007; Hjern et al. 2010; Kogan et al. 2009; Pastor and Rueben 2008; Scahill et al. 1999). It is unclear whether this effect is due to differential reporting about the same level of difficulties between low and high SES groups or whether children in different socio-economic groups have truly varying symptom levels, perhaps due to increased stressors in low SES households, ~~or early environmental insults more common in low SES groups~~ (Boyle et al. 2011). Some US studies have found a relationship between measures of social and economic advantage and having a child with ASD (Fountain et al. 2011; Kogan et al. 2009), in contrast to our findings which found a link with socio-economic disadvantage in unadjusted analysis. The results did not show any link between ASD and older motherhood, or diagnosed maternal depression, unlike other studies (Daniels et al. 2008; Sandin et al. 2012). There is little evidence of an association between ASD and ethnicity in studies outside the US (Zaroff and Uhm 2011). Despite the oversampling of ethnic populations in MCS, numbers were too low to give a meaningful picture of identification within specific ethnic groups for either disorder: but this is not to say such associations do not exist.

Conclusions

The prevalence for clinically identified ASD reported by parents is higher than previously estimated. Our findings do suggest that the proportion of children recognised with ADHD by doctors in the UK is lower than the proportion of children diagnosed in the US (1.4 % in this UK estimate as opposed to 6.3 % recorded in the closest US comparator). This difference in clinical practice in UK settings may be due to truly lower levels of symptoms, or differing cultural factors in consideration of the ADHD label. Our study underlines the need to establish whether trends are underpinned by increasing risk, or merely reflect changes in diagnostic practice. On-going work to establish which groups of children are most often identified with each condition is important as differing contexts may lead to children either missing out on health services, and/or or over-diagnosis.

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