Birth weight and stuttering: Evidence from three birth cohorts

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ABSTRACT

Purpose Previous studies have produced conflicting results with regard to the association between birth weight and developmental stuttering. This study sought to determine whether birth weight was associated with childhood and/or adolescent stuttering in three British birth cohort samples.

Methods Logistic regression analyses were carried out on data from the Millenium Cohort Study (MCS), British Cohort Study (BCS70) and National Child Development Study (NCDS), whose initial cohorts comprised over 56,000 individuals. The outcome variables were parent-reported stuttering in childhood or in adolescence; the predictors, based on prior research, were birth weight, sex, multiple birth status, vocabulary score and mother's level of education. Birth weight was analysed both as a categorical variable (low birth weight, <2500g; normal range; high birth weight, ≥ 4000g) and as a continuous variable. Separate analyses were carried out to determine the impact of birth weight and the other predictors on stuttering during childhood (age 3, 5 and 7 and MCS, BCS70 and NCDS, respectively) or at age 16, when developmental stuttering is likely to be persistent.

Results None of the multivariate analyses revealed an association between birth weight and parent-reported stuttering. Sex was a significant predictor of stuttering in all the analyses, with males 1.6 to 3.6 times more likely than females to stutter.

Conclusion Our results suggest that birth weight is not a clinically useful predictor of childhood or persistent stuttering.

Keywords: birth weight; stuttering; birth cohort.

1. Introduction

Many studies have attempted to identify risk factors associated with stuttering; see, for example, Andrews & Harris (1964), Ardila, Bateman, & Niño (1994), Berry (1938a, b), Cook, Howell, & Donlan (2013), Craig, Hancock, Tran, Craig & Peters, (2002), Howell (2013), Howell & Davis (201), Johnson (1955), Månsson (2000), Reilly, Onslow, Packman, Wake, Bavin, Prior, et al. (2009), and Yairi & Ambrose (2013). Packman (2012) has proposed a model of developmental stuttering whose central hypothesis is that the fundamental cause of the disorder is a neural deficit. This hypothesis is consistent with the findings of many recent studies which have reported structural and functional abnormalities in the brains of people who stutter (Chang, Erickson, Ambrose, Hasegawa-Johnson & Ludlow, 2008; Chang, Horwitz, Ostuni, Reynolds & Ludlow, 2011; Cykowski, Fox, Ingham, Ingham & Robin, 2010; Watkins, Smith, Davis & Howell, 2008). One risk factor for abnormal neural development is birth weight (Walhovd, Fjell, Brown, et al., 2012). Low birth weight is well documented as a major determinant of mortality, morbidity and disability in infancy and childhood and also has a long-term impact on health outcomes in adult life (World Health Organisation, 1992). High birth weight can be associated with complications during childbirth (Zhang, Decker, Platt et al, 2008). Either of these variations might have an impact on neurological development that could lead to stuttering.

Two recent studies have reported conflicting results regarding the association between birth weight and developmental stuttering. Reilly, Onslow, Packman et al (2009) used a birth cohort sample of 1612 children to identify the predictors of therapist-diagnosed stuttering in one hundred and fifty eight 3-year-olds. As well as birth weight, they examined the influence of child's temperament, language development, maternal mental health, maternal education, sex, premature birth status, birth order, twinning, socio-economic status, and family history of stuttering. They found that cohort members (CMs) who stuttered at age 3 were significantly more likely than other CMs to be male, be a twin, have a high vocabulary score at 2 years of age, and be the child of a highly-educated mother. Birth weight was not a significant predictor of stuttering in their study.

By contrast, Boulet, Schieve & Boyle (2011) did find an association between birth weight and stuttering. They examined the relationship between birth weight and several developmental disorders, including stuttering, in a US parent survey that studied 87,578 children of ages 3-17 years; approximately 25% were 3-5 year olds. The parent-reported data included the child's birth weight and whether the child had stuttered during the previous year. In their analyses of all of the developmental disorders, the authors adjusted for the same factors: age, sex, race, household income, maternal education and year of survey. Using birth weights of 3500g to 3999g as the reference category, they found that birth weights up to 2999g were between 1.3 and 3.0 times more likely to be associated with stuttering.

One difference between the two studies that might explain this discrepancy relates to the different age ranges of the participants in the two studies and potential differences between children who recover from stuttering and those whose stuttering is persistent. Perhaps birth weight is only a predictor of persistent developmental stuttering. Since there is a high rate of spontaneous recovery among pre-schoolers who stutter (Ambrose , Cox &Yairi, 1997; Yairi , Ambrose, Paden & Throneburg, 1996), the majority of the children in Reilly et al's (2009) sample would be likely to recover. Boulet et al's (2011) much larger sample included participants in their teens; since most, if not all, of these older participants who stuttered would belong in the persistent category, Boulet et al's sample could contain a higher proportion of participants with persistent stuttering than Reilly et al's. Unfortunately, the way in which Boulet et al report the data does not allow this possibility to be examined.

The aim of the present study was to determine the relationship between birth weight and developmental stuttering in three British birth cohort data sets which contain data from over 56,000 participants in total. Using binary logistic regression analyses, we attempted to control for the factors that Reilly et al (2009) found to be significant predictors of stuttering. We first considered the relationship between birth weight plus these other factors and parent-reported stuttering during childhood. We then considered these factors in CMs at age 16, comparing those who were still reported to stutter at this age with those who had never been reported to stutter. Based on the reasoning in the previous paragraph, we hypothesised that birth weight would be significantly associated with developmental stuttering at age 16 but not during childhood.

2. Method

2.1. Data sources

Data from three British birth cohorts were analysed. A birth cohort study is a type of longitudinal research that follows the same group of individuals throughout their lives. The three British birth cohorts that were analysed in this study were designed as a resource for researchers and policy-makers who were interested in issues such as how early life circumstances and experiences influence later life outcomes, how a person's health, wealth, family, parenting, education, employment and social attitudes are linked, and how these aspects of life vary for different individuals. The datasets form a very rich resource, with information gathered from parents, siblings, teachers and doctors as well as the cohort members themselves. They cover a wide range of aspects of the cohort members' lives, including health, education, relationships, and cognitive development. They use a variety of methods of data collection including questionnaires, cognitive tests and biometric measurements. Each dataset comprises several tens of thousands of variables.

In each analysis the outcome variable was parent-reported stuttering and the predictor variables were those that were found by Reilly et al (2009) to be significant predictors of stuttering. It is worth noting that in secondary data analysis such as that reported here, selection of variables is constrained by those that are available, and occasionally, when the optimal variable has not been collected, it is necessary to substitute a proxy.

The three datasets that were used in the present study are briefly outlined below. For further information see http://www.cls.ioe.ac.uk/. This website also provides resources for identifying other variables that are available for analysis.

National Child Development Study (NCDS)

The original cohort of NCDS comprised 18,558 children who were either born in Britain in a particular week in 1958, or were born overseas in the same week but moved to Britain before age 16. Surveys were conducted at birth and when CMs were 7, 11, 16, 23, 33, 42, 46 and 50 years of age. Birth weight, sex, multiple birth status and the mother's age of leaving full-time education[1] were usually recorded during the first week of life by the midwife who delivered the child. When CMs were 7 years old, parents were asked "Has there ever been any stammer or stutter?" Also at age 7, the CMs completed the 30-item Southgate Reading Test[2] which involved selecting, from a set of 5 options, the printed word that corresponded to a picture stimulus. When CMs were 16 years old, parents were asked "Does he/she stammer or stutter?"

1970 British Cohort Study (BCS70)

[1] The minimum school leaving age in Britain was 12 until 1918, 14 until 1947, and 15 until 1972, when it became 16. Education is compulsory until the school leaving age. Other potentially more sensitive measures of maternal education, relating to highest qualification achieved, were only available for two of the datasets; since preliminary analyses indicated that substitution of this measure of maternal education made no difference to the regression results, for simplicity we used the dichotomous variable of whether or not the mother stayed on at school beyond the minimum school leaving age.

[2] In this study, the Southgate Reading Test (Southgate, 1962) is used as a proxy for a vocabulary test, as no test similar to the vocabulary measures collected in the other two datasets was completed in NCDS. Shepherd (2012d) explains that the test was selected because it successfully identified what he describes as 'backward readers'. No information is available about the correlation between this test and other vocabulary measures.

The 18,737 CMs of BCS70 were all born in Britain in one particular week in 1970, or were born abroad in the same week but moved to Britain before age 16. Data collection occurred at birth and at ages 5, 10, 16, 26, 30, 34 and 38. Birth weight, sex, multiple birth status and the mother's age of leaving full-time education were usually recorded during the first week of life by the midwife who delivered the child. When CMs were 5 years old their parents were asked "Has (CM) ever had a stammer or stutter?" Also at age 5, the CMs completed the 56-item English Picture Vocabulary Test (EPVT; Brimer & Dunn, 1962), an adaptation of the Peabody Picture Vocabulary Test. When CMs were 16 years old their parents were again asked about stuttering.

Millenium Cohort Study (MCS)

The original cohort of MCS comprised 18,818 children sampled from all live births in the United Kingdom over 12 months from 1st September 2000 in England and Wales and 1st December 2000 in Scotland and Northern Ireland. The sample was designed to over-represent ethnic minorities in England, families with high child poverty, and residents of the three smaller countries of the United Kingdom; this non-random sampling has implications for the analysis of the data, and use of specific statistical weighting procedures is recommended (Plewis, 2007). To date, information about the CMs has been gathered at age 9 months and when they were 3, 5, 7 and 11 years old. During the first data collection sweep, parent-reported data included the CM's sex, multiple birth status and birth weight, and the age at which the mother completed full-time education. When CMs were 3 years old, they completed the 36-item naming vocabulary sub-test of the British Abilities Scales (Elliott, 1983) and during the same sweep parents were asked 'Do you have any concerns about [CM]'s speech and language?', with one response option being 'S/he stutters'.

2.2. Analyses

Logistic regression is the statistical tool that is appropriate for the analysis of data from large samples where the goal is the establish predictive relationships between a binary outcome variable, such as whether or not a person stutters, and one or more other variables (for a recent discussion of the technique in the context of risk factors for stuttering, see Reed & Wu, 2013). Univariate and multivariate analyses can be performed. Univariate analysis is concerned with the relationship between the outcome and one other factor, while multivariate analysis takes into account several factors simultaneously. Because the multivariate analysis examines the influence of each predictor while controlling for the other variables of interest, this is the analysis that provides a true picture of the effect of a factor. All statistical analyses were carried out using SPSS 18 for Windows.

For each dataset in the present study, logistic regression analyses were carried out with parent-reported stuttering as the outcome variable. A set of univariate analyses was carried out to determine the association between birth weight and likelihood of stuttering. To control for the other variables that Reilly et al (2009) found to be associated with stuttering, multivariate analyses were then conducted, with birth weight, sex, multiple birth status, vocabulary score and maternal education level as predictors.

The multivariate analyses employed the backward stepwise method whereby all variables are initially entered into the analysis and one non-significant variable is removed at each step until only significant variables remain in the final model. Stepwise regression was considered the most appropriate method of analysis as the final model has fewer correlated variables and it can screen out those variables observed to be less informative (Pasha, 2002). It is particularly useful when there are missing data for independent variables (Roth 1994). An advantage of backward stepwise regression over forward stepwise regression is that it permits the combined effects of variables to be taken into account (Andersen 2010) whereas forward stepwise regression will only take into account the combined effects of any variables that manage to enter the model. Significance criteria for inclusion in and exclusion from the model were 0.05 and 0.10 respectively.

As noted in the previous section, the sampling design of MCS was such that it would be invalid to assume simple random sampling and independence of observations, because the resulting significance tests would be invalid. Instead, weights were used to adjust for unequal sample selection probabilities, attrition and non-response. Jones and Ketende (2010) describe the appropriate method to use with the MCS data and provide SPSS code for carrying out the weighting procedure.

Analyses of childhood stuttering were carried out using data from the MCS, BCS70 and NCDS samples when CMs were 3, 5 and 7 years old, respectively. Analyses of stuttering at age 16 were carried out using the BCS70 and NCDS cohorts.

In the analyses reported here, birth weight was analysed as a categorical variable, with weights <2500g classified as low birth weight and ≥4000g as high birth weight (World Health Organisation, 1992; Zhang, Decker, Platt, et al, 2008). Additional analyses were conducted with birth weight as a continuous variable, and where results differed this is noted.

2.3. Ethical Review

Ethical review was carried out at the Centre for Longitudinal Studies, the South West MREC and the London MREC (Shepherd, 2012a, b, c). The Centre for Longitudinal Studies at the Institute of Education (http://www.cls.ioe.ac.uk/) collects the data and the UK Data Service (http://ukdataservice.ac.uk/) curates it in a manner that protects confidentiality for cohort participants. Full anonymity is assured. The original ethics approval allows registered users of the UK Data Service to use the data as long as they abide by the terms and conditions of the Service, which ensure appropriate and ethical use of the data. Research participants are protected and personal data safeguarded. The research described here was carried out in line with the conditions described above.

3. Results

The key hypothesis in the present study concerned the relationship between birth weight and stuttering. It was hypothesised that evidence for this relationship would be found for adolescent (persistent) stuttering but not for childhood stuttering; but in fact, the analyses reported below provide no support for the hypothesis at either age. The only consistently significant predictor of stuttering across all samples was cohort member's sex, with males two to three times more likely than females to stutter. In some analyses there was an association between the vocabulary measure and stuttering, and in one between multiple birth and stuttering.

Detailed results for childhood and adolescent stuttering are provided below. Note that in Tables 2 and 4, N differs from variable to variable because of different response levels for different variables. For example, in the first column of Table 2 the N for cohort members who were not reported to stutter was higher for the variable 'Cohort member sex' than for the variable 'Birth weight category' because there were 10 cohort members in this group for whom birth weight information was not available.

3.1. Analyses of childhood stuttering: data from the MCS, BCS70 and NCDS cohorts

For all three samples, mean vocabulary scores are shown in Table 1 and the distribution of CMs with respect to categorical variables in Table 2.

Table 1: Mean vocabulary scores of cohort members who stuttered versus controls

	No stutter Mean (s.d.)	Stutter Mean (s.d.)
MCS, age 3	74.36 (17.57)	73.80 (14.12)
BCS70, age 5*	33.39 (9.30)	31.73 (9.91)
NCDS, age 7*	23.53 (7.02)	21.58 (7.92)
BCS70, age 16	33.75 (9.19)	32.74 (9.53)
NCDS, age 16*	23.96 (6.70)	19.87 (8.53)

Note: MCS cohort members completed the naming vocabulary subtest of the British Abilities Scales at age 3; BCS70 cohort members completed the English Picture Vocabulary Test at age 5; NCDS cohort members completed the Southgate Reading Test at age 7.
* $p \leq 0.001$ in final multivariate model.

In the univariate analysis, the relationship between birth weight category and childhood stuttering was weakly significant (p=0.047). When birth weight was entered as a continuous variable, the association was not significant. In the final model of the multivariate analysis, shown in Table 3, although being male was significantly associated with stuttering, birth weight was not entered into the analysis as it had been non-significant at an earlier step. The model predicted little of the variance (Nagelkerke R^2 =0.006).

In the MCS sample, 270 CMs (1.4% of the full cohort; 2.0% of those answering the question about stuttering at age 3) were reported by their parents to have stuttered at age 3. As noted in Section 2.2., the data from MCS needed to be weighted in order for the regression analyses to provide results that are generalizable to the population and comparable to the analyses of BCS70 and NCDS.

In the BCS70 dataset, 793 CMs (4.2% of the full cohort; 6.6% of those answering the question about stuttering at age 5) were reported by their parents to have stuttered at or before age 5. There was no significant relationship between birth weight category and childhood stuttering in the univariate analysis (p=0.785). In the final model of the multivariate analysis, shown in Table 3, being male and

Table 2: Distribution of cohort members with respect to categorical variables (childhood stuttering)

	MCS (age 3)				BCS70 (at or before 5)				NCDS (at or before 7)			
	No stutter		Stutter		No stutter		Stutter		No stutter		Stutter	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Birth weight category												
Low (< 2500g)	855	(6.7)	14	(5.6)	655	(6.0)	48	(6.3)	726	(5.3)	53	(5.7)
Normal range (2500-3900g)	10402	(81.3)	192	(76.2)	9329	(85.2)	656	(85.6)	11765	(85.9)	793	(85.9)
High (≥4000g)	1544	(12.1)	46	(18.3)	960	(8.8)	62	(8.1)	1202	(8.8)	77	(8.3)
Total	12801		252		10944		766		13693		923	
Cohort member sex												
Female	6585	(45.3)	95	(37.7)	5489	(50.1)	260	(33.9)	6886	(50.3)	302	(32.7)
Male	6248	(51.3)	157	(62.3)	5465	(49.9)	506	(66.1)	6807	(49.7)	621	(67.3)
Total	12833		252		10954		766		13693		923	
Maternal education												
Left at/before minimum age	5998	(47.0)	130	(51.6)	8959	(82.7)	642	(84.9)	9903	(75.0)	688	(77.6)
Stayed on after minimum age	6764	(53.0)	122	(48.4)	1875	(17.3)	114	(15.1)	3298	(25.0)	199	(22.4)
Total	12762		252		10834		756		13201		887	
Multiple birth status												
Singleton	12643	(98.5)	247	(98.0)	10737	(98.0)	748	(97.7)	13375	(97.7)	901	(97.6)
Twin or triplet	190	(1.5)	5	(2.0)	217	(2.0)	18	(2.3)	318	(2.3)	22	(2.4)
Total	12833		252		10954		766		13693		923	

Table 3: Factors associated with childhood stuttering in final multivariate models

		Stuttering at 3 (MCS; weighted values) OR (95% CI)	Stuttering at/before 5 (BCS70) OR (95% CI)	Stuttering at/before 7 (NCDS) OR (95% CI)
Birth weight category		Not significant – removed from model	Not significant – removed from model	Not significant – removed from model
Sex				
	Female	1.00	1.00	1.00
	Male	1.59 (1.20 to 2.10) p = 0.001	2.03 (1.71 to 2.40) p < 0.001	1.84 (1.59 to 2.12) p < 0.001
Birth status		Not significant – removed from model	Not significant – removed from model	Not significant – removed from model
Maternal education		Not significant – removed from model	Not significant – removed from model	Not significant – removed from model
Vocabulary score		Not significant – removed from model	0.98 (0.97 to 0.99) p < 0.001	0.97 (0.96 to 0.98) p < 0.001

having a lower vocabulary score were significantly associated with stuttering, but birth weight was not entered into the analysis as it had been non-significant at an earlier step. The model predicted little of the variance (Nagelkerke R^2 =0.025).

In the NCDS dataset, 923 CMs (5.0% of the full cohort; 6.3% of those answering the question about stuttering at age 7) were reported by their parents to have stuttered at or before age 7. There was no significant relationship between birth weight category and childhood stuttering in the univariate analysis (p=0.778). In the final model of the multivariate analysis, shown in Table 3, being male and having a lower vocabulary score were significantly associated with stuttering, but birth weight was not entered into the analysis as it had been non-significant at an earlier step. The model predicted little of the variance (Nagelkerke R^2 =0.025).

Additional regression analyses were carried out excluding CMs in the NCDS and BCS70 samples who were born abroad (NCDS N=1142, 6.2% of the original sample; BCS70 N = 355, 1.9% of the original sample). The pattern of results did not differ from those reported in Table 3. Further analyses were also conducted excluding CMs with evidence of other neurological, intellectual, hearing or vision problems; because of the way that the questions were asked in the different datasets, the prevalence of such problems varied widely (NCDS N = 648, 3.5% of the original sample; BCS70 N=759, 4.1% of the original sample; MCS N =1645, 8.4% of the original sample). These analyses produced the same pattern of results as that reported in Table 3.

Analyses of persistent stuttering: data from the BCS70 and NCDS cohorts

For the analyses comparing CMs who were reported to stutter at 16 with those who had never been reported to have any form of speech difficulty, CMs whose parents reported that they had recovered from earlier stuttering were excluded. Only BCS70 and NCDS data were included in these analyses;

Table 4: Distribution of cohort members with respect to categorical variables (stuttering at age 16)

	BCS70				NCDS			
	No stutter		Stutter		No stutter		Stutter	
	N	(%)	N	(%)	N	(%)	N	(%)
Birth weight category								
Low (< 2500g)	473	(6.2)	4	(9.3)	517	(5.1)	17	(7.8)
Normal (2500-3900)	6559	(85.6)	37	(86.0)	8850	(86.9)	178	(82.0)
High (≥4000g)	634	(8.3)	2	(4.7)	822	(8.1)	22	(10.1)
Total	7666		43		10189		217	
Cohort member sex								
Female	4020	(52.4)	14	(32.6)	5153	(50.6)	43	(19.8)
Male	3651	(47.6)	29	(67.4)	5036	(49.4)	174	(80.2)
Total	7671		43		10189		217	
Maternal education								
Left at or before min age	6221	(81.9)	36	(85.7)	7144	(74.7)	166	(81.8)
Stayed on after min age	1378	(18.1)	6	(14.3)	2419	(25.3)	37	(18.2)
Total	7599		42		9563		203	
Multiple birth status								
Singleton	7519	(98.0)	39	(90.7)	9644	(97.9)	202	(97.1)
Twin or triplet	153	(2.0)	4	(9.3)	207	(2.1)	6	(2.9)
Total	7672		43		9851		208	

Note: due to rounding, percentages may not add up to 100.

Table 5: Factors associated with stuttering at 16 in final multivariate models

	BCS70, age 16 OR (95% CI)	NCDS, age 16 OR (95% CI)
Birth weight category	Not significant – removed from model	Not significant – removed from model
Sex		
Female	1.00	1.00
Male	3.29 (2.26 to 4.29) p = 0.012	3.60 (2.51 to 5.17) p < 0.001
Multiple birth status		
Singleton	1.00	Not significant – removed from model
Twin or triplet	4.92 (1.74 to 13.98) p = 0.003	
Maternal education	Not significant – removed from model	Not significant – removed from model
Vocabulary score	Not significant – removed from model	0.94 (0.92 to 0.96) p < 0.001

MCS data were only available up to age 8. For both samples, mean vocabulary scores are shown in Table 1 and the distribution of CMs with respect to categorical variables in Table 4.

In the BCS70 dataset, 48 CMs (0.3% of the full cohort; 0.6% of those responding to the question about stuttering at age 16) were reported to stutter at age 16. There was no significant relationship between birth weight category and childhood stuttering in the univariate analysis (p=0.517). In the final model of the multivariate analysis, shown in Table 5, persistent stuttering was significantly associated with being male and being a twin or triplet, but not with birth weight, which was not included in the final model as it had been non-significant at an earlier step; the model was weak, predicting very little of the variance (Nagelkerke R^2 =0.025).

In the NCDS dataset, 217 CMs (1.2% of the full cohort; 2.1% of those answering the question about stuttering at age 16) were reported to stutter at age 16. There was no significant relationship between birth weight category and childhood stuttering in the univariate analysis (p=.092). In the final model of the multivariate analysis, shown in Table 5, persistent stuttering was significantly associated with being male and having a lower vocabulary score, but birth weight was not entered into the analysis as it had been non-significant at an earlier step. The model was weak, predicting little of the variance (Nagelkerke R^2 =0.058).

Additional analyses of the data from CMs at age 16 were conducted to control for overseas birth effects and the possible confounding effects of comorbid conditions. In all of the additional analyses the pattern of results was as reported in Table 5.

4. Discussion

The main finding of this study is that birth weight is not a significant predictor of stuttering. Analysis of the NCDS and BCS70 datasets failed to reveal a significant association between the two variables for either childhood or adolescent (persistent) stuttering. Although univariate analysis of the age 3 MCS data revealed a weakly significant relationship between the variables, in the adjusted analysis, the association was non-significant.

The absence of a significant association between birth weight and stuttering supports the findings of Reilly et al (2009) but contradicts those of Boulet et al (2011). We hypothesised that this could be because of a higher proportion of older participants with persistent stuttering in the Boulet et al sample, but this explanation seems unlikely given that the present study did not reveal a significant association between the variables in the NCDS and BCS70 age 16 samples.

It is important to report null results of this kind in order to avoid the publication bias that is a common feature of clinical research (Easterbrook, Gopalan, Berlin & Matthews, 1991). Low and high birth weight have been associated with a range of developmental disorders (World Health Organisation, 1992; Zhang, Decker, Platt et al, 2008), and it would not be surprising if birth weight outside of the normal range were also a risk factor for stuttering. From the point of view of a clinician constructing a client's individual profile, it is important to know which factors are less likely to be relevant, as well as which factors are potential risks.

One limitation that the present study shares with that of Boulet et al is that it used parental report, rather than clinical diagnosis, to identify cases of stuttering. However, Reilly et al found that at least 85% of parents who reported that their 3-year-olds stuttered were correct; given the possibility of rapid spontaneous recovery occurring between the time of parental report and clinician examination, this figure could well be higher. Further limitations may be due to measurement constraints. For example, it is possible that parental interpretation of the term 'stuttering' may have varied over the decades covered by the three birth cohorts; children's stuttering was asked about at specific time points in each cohort requiring a degree of recall; and the very act of measuring (or asking about) the characteristic of stuttering may have effect of constraining (or limiting) the reporting behaviour of those being asked about the stuttering activity. Longitudinal studies such as this, which cover an extended time period, are also likely to be subject to significant attrition. These limitations are inherent in population studies, but the fact that relatively consistent patterns are observed across all three datasets in the present study, at least with regard to the relationship between birth weight and stuttering, may offer some reassurance as to the validity of the results. Nonetheless, it would be prudent to verify these findings in future work.

The final models of the multivariate analyses reported here accounted for relatively little of the variance in the data. Other factors not included in these analyses might increase the predictive power of the model. Surveying recent research into the epidemiology of stuttering, Yairi and Ambrose (2013) discuss a number of such factors, including genetics, different stuttering subtypes, and effects of race, ethnicity, culture, bilingualism, and socio-economic status. Future research using birth cohort data should aim to take these factors into account where possible.

The most reliable predictor of both childhood and adolescent stuttering in this study was the CM's sex, with males two to three times more likely than females to experience the disorder. This finding is consistent with results from other studies (e.g. Andrews & Harris, 1964; Craig et al, 2002; Reilly et al, 2009; Yairi & Ambrose,2013), as is the increase of the male to female proportion of stuttering in adolescence compared to childhood, reflecting a higher rate of spontaneous recovery among females (Yairi & Ambrose, 1999).

No association was found between maternal education and the likelihood of stuttering. With regard to other predictors, a more mixed pattern emerged. In the BCS70 age 16 analysis, twins or triplets were more likely to stutter, but multiple birth status was not significant in any other analysis. Vocabulary ability was significantly associated with stuttering in some but not all of the analyses, but the direction of the relationship was the opposite of that reported by Reilly et al (2009). One factor that might explain the difference between Reilly et al's vocabulary findings and those from BCS70 and NCDS in the present study is that Reilly's study included only children who had started to stutter by age 3 years, that is, early-onset children, who might have more advanced language skills. However, since the MCS data considered here also related to 3-year-olds, this explanation may not be correct. Given that different vocabulary measures were used in the three data sets, and that Reilly et al used yet another measure, this variation is perhaps not surprising. A further possible explanation may relate to the fact that the datasets examined here included only limited information about language ability, and as a result, the analyses that can be conducted may not be sensitive enough to address the complex and dynamic relationship which may exist between language and fluency. The task of examining this relationship in a population study is challenging, unless it has been designed with this specific question in mind. Future work may clarify this issue.

It is worth noting that the reported prevalence of childhood stuttering among the 3-year-olds in the MCS sample was much lower than in the other two datasets, which focused on older children, and also much lower than that reported by Reilly et al (2009) who also analysed data from 3-year-olds. Within the British birth cohort data, it is possible that this discrepancy resulted from differences in the method of data collection. The health visitors who carried out the BCS70 and NCDS childhood interviews may have been able to answer parents' queries about what was meant by the terms 'stutter' and 'stammer' in a way that the non-clinical interviewers who collected the MCS data might not. The difference between the prevalence levels in the Reilly et al study and the MCS data may be a consequence of the more targeted subject matter of the former. Reilly et al's study of stuttering formed part of a larger study that focused specifically on speech and language development, and included detailed information resources specifically alerting parents to the features to look out for in early developmental stuttering. In MCS, the question about stuttering was just one of several hundred addressing a wide range of topics that were asked of the cohort members' parents during the early years, and this, coupled with the fact that the question was asked by non-specialist interviewers, may have led to under-reporting of the condition. Alternatively, perhaps the prevalence figures reported by Reilly et al (2009) are over-estimates.

Identifying the factors associated with stuttering is important if scarce clinical resources are to be targeted effectively. Since we could find no evidence of an association between low or high birth weight and stuttering, our key conclusion from the present study is that birth weight is not a clinically useful predictor of childhood or adolescent stuttering.

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