

# Birth weight, childhood socioeconomic environment, and cognitive development in the 1958 British birth cohort study

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## Abstract

**Objectives** To examine the combined effect of social class and weight at birth on cognitive trajectories during school age and the associations between birth weight and educational outcomes through to 33 years.

**Design** Longitudinal, population based, birth cohort study.

**Participants** 10 845 males and females born during 3-9 March 1958 with information on birth weight, social class, and cognitive tests.

**Main outcome measures** Reading, maths, draw a man, copying designs, verbal and non-verbal ability tests at ages 7, 11, and 16, highest qualifications achieved by 33, and trajectories of maths standardised scores at 7-16 years.

**Results** The outcome of all childhood cognitive tests and educational achievements improved significantly with increasing birth weight. Analysis of maths scores at 7 and of highest qualifications achieved by 33 showed that the relations were robust to adjustment for potential confounding factors. For each kilogram increase in birth weight, maths z score increased by 0.17 (adjusted estimate 0.15, 95% confidence interval 0.10 to 0.21) for males and 0.21 (0.20, 0.14 to 0.25) for females. Trajectories of maths z scores between 7 and 16 years diverged for different social class groups: participants from classes I and II increased their relative position on the score with increasing age, whereas classes IV and V showed a relative decline with increasing age. Birth weight explained much less of the variation in cognition than did social class (range 0.5-1.5% v 2.9-12.5%).

**Conclusions** The postnatal environment has an overwhelming influence on cognitive function through to early adulthood, but these strong effects do not explain the weaker but independent association with birth weight.

## Introduction

A consistent association between weight at birth and cognitive development has been established within cohorts born during different periods in the 20th century.<sup>1-4</sup> Earlier studies that focused on low birth weight or small for gestational age infants showed an increased incidence of neurological deficits or poorer cognitive skills through childhood compared with counterparts of normal weight.<sup>5-9</sup> The association between weight at birth and later cognition persists across the whole spectrum of birth weight, rather than being confined to an extreme group and is not explained by confounding or effect modification by social factors.<sup>1-4 10</sup> Most studies have investigated cognition at one age only.<sup>1 3 10 11</sup>

Socioeconomic background also has a strong influence on cognitive function in children, which perhaps

exceeds the impact of birth weight.<sup>1</sup> Yet few studies have constructed cognitive trajectories through childhood and adolescence from which the combined contributions of birth weight and social environment can be assessed. Such analyses are required to establish whether effects of birth weight and social environment persist with increasing age. We aimed to examine the combined effect of birth weight and socioeconomic environment on cognitive trajectories during childhood. We investigated the influence of birth weight on seven measures of cognitive and educational outcome at 7, 11, 16, and 33 years.

## Methods

### Sample

The 1958 birth cohort comprises individuals born during 3-9 March 1958 in England, Scotland, and Wales.<sup>12 13</sup> Our analyses are based on 10 845 participants with data on birth weight, gestational age, maths scores at 7 years, and potential confounding factors.

### Measures

#### School tests

At 7, 11, and 16, the participants took age appropriate tests at school for maths, reading, general ability, and perceptual and motor skills (see [bmj.com](http://bmj.com)).<sup>14-16</sup> Highest qualifications achieved by age 33 were categorised as no qualifications, less than O level (or equivalent), O level (or equivalent), A level (or equivalent), or higher qualification.

#### Birth weight and gestational age

Birth weight was recorded in pounds and ounces and converted into kilograms.<sup>12</sup> Duration of gestation was estimated from the date of the last menstrual period reported by the mother and checked against general practitioner records. The z (standard deviation) scores of birth weight for gestational age were calculated by sex for each week of gestation.

#### Social class

Social position at birth was based on the father's occupation in 1958, classified according to the registrar general's scale, ranging from class I (professional) to V (unskilled manual). Groups I and II were combined, as were groups IV and V. Households with no male head of household were included with group IV and V.

#### Confounders

Potential confounders included maternal age, breast feeding, parental education, and parity. Maternal and paternal education were coded according to whether or not they had stayed in school beyond minimum school leaving age (14 years until 1948, 15 years thereafter). Infant feeding was recorded as ever breast fed,

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**Table 1** Mean z scores (95% confidence intervals) for maths tests at ages 7, 11, and 16 years according to birth weight

Age at test	No	Birth weight (g)				
		<2500	2501-3000	3001-3500	3501-4000	>4000
Males:						
Age 7	6216	-0.13 (-0.27 to 0.01)	-0.08 (-0.14 to -0.01)	0.07 (0.03 to 0.12)	0.14 (0.10 to 0.18)	0.17 (0.10 to 0.24)
Age 11	5820	-0.22 (-0.36 to -0.08)	-0.14 (-0.20 to -0.07)	0.04 (0.00 to 0.08)	0.15 (0.11 to 0.20)	0.21 (0.14 to 0.29)
Age 16	4854	-0.14 (-0.27 to 0.00)	-0.10 (-0.17 to -0.03)	0.13 (0.09 to 0.18)	0.22 (0.17 to 0.27)	0.19 (0.11 to 0.27)
Females:						
Age 7	5908	-0.33 (-0.44 to -0.22)	-0.12 (-0.17 to -0.06)	-0.01 (-0.05 to 0.03)	0.08 (0.03 to 0.13)	0.12 (0.03 to 0.21)
Age 11	5529	-0.37 (-0.47 to -0.27)	-0.08 (-0.13 to -0.02)	0.02 (-0.02 to 0.06)	0.17 (0.12 to 0.22)	0.11 (0.01 to 0.21)
Age 16	4653	-0.42 (-0.53 to -0.32)	-0.14 (-0.19 to -0.08)	-0.07 (-0.12 to -0.03)	0.03 (-0.03 to 0.08)	0.06 (-0.05 to 0.17)

and parity was recorded as 0, 1, or > 1. Maternal age was recorded at the birth of the cohort member as age at last birthday.

**Data analysis**

We calculated z scores from the raw maths scores for both sexes combined to allow comparisons across the three test ages (7, 11, 16). A child with a z score of 0 at each age had an average score on each occasion relative to others. An increasing z score with age signalled improvement in relative achievement.

We used linear regression to examine whether the effect of birth weight (continuous variable) on maths at 7 years was robust to adjustment for gestational age and potential confounding factors. We tested for interactions of birth weight with these confounding factors plus sex. Linear regression models provide estimates separately for ages 7, 11, and 16 of the percentage of variance explained by birth weight and class at birth. We repeated the linear regression analyses with highest qualifications achieved by 33 years.

We plotted trajectories of z score for maths from age 7 to 16 according to birth weight and class at birth, and we used a repeated measures multilevel model for the longitudinal analysis.<sup>17</sup>

**Results**

All cognitive tests and educational achievements differed across birth weight categories from ages 7 to 33 (see *bmj.com*). For both sexes there was a significant trend of increasing mean scores with increasing birth weight—for example, the proportion of men with higher qualifications increased from 26% in the lowest (≤2500 g) birth weight group to 34% in the highest (>4000 g). For women equivalent

percentages were 17% and 28%. Standardised maths scores increased with increasing birth weight at all ages: z scores differed by between 0.23 and 0.48 between the highest and lowest birth weight categories for ages 7 to 16 (table 1).

The relation between birth weight and maths z scores at 7 years was robust to adjustment for gestational age, maternal age, social class, parity, sex, breast feeding, and parental education (see *bmj.com*). The score increased by 0.17 and 0.19 respectively for males and females for each kilogram increase in birth weight. Estimates were little changed after adjustment. Excluding preterm births or participants with disability did not change the relations.

Social background had a strong effect on maths scores, with children from class I and II gaining higher scores than those from class IV and V. The percentage of variance in maths scores explained by class at birth increased from about 3% at age 7 to 12% at age 16, whereas the percentage for birth weight remained at around 1% (table 2).

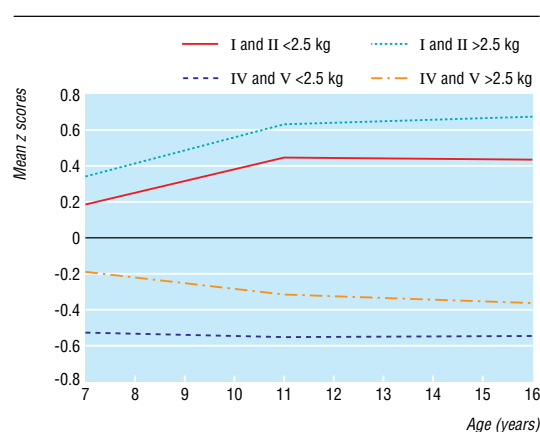
Participants of low (≤2500 g) birth weight from class I and II had higher average z scores for maths than participants of normal (>2500 kg) birth weight from class IV and V (figure). The maths scores of children of both low and normal birth weight from class I and II showed a relative increase between age 7 and 16. In class IV and V, however, the scores of participants of normal birth weight showed a relative decline with age. The figure illustrates the extent to which advantage conferred by higher class applies to individuals of low birth weight, both in initial scores attained at age 7 and in the trajectory through adolescence.

The association between maths score and social class seemed to strengthen with age (figure). This was confirmed in a multilevel growth model, showing a significant interaction between class of origin and age. An effect of birth weight on the intercept of the growth trajectory for maths scores remained significant after adjustment for all covariates. No interaction was found between social class and birth weight or between sex and birth weight.

In analyses of adult educational level, highest qualifications measured on a 5 point scale increased by 0.17 and 0.22, respectively, for males and females for each kilogram increase in birth weight. This effect was robust to adjustment for gestational age, maternal age, social class, parity, sex, breast feeding, and parental education. The percentage variance in adult educational qualifications explained by birth weight (< 1% for both sexes) was smaller than social class at birth (9% for males, 11% for females) (table 2).

**Table 2** Percentage variance explained (adjusted R<sup>2</sup>) for linear regression of birth weight and social class at birth on maths z scores at 7, 11, and 16 years and highest adult qualifications at age 33

	No	Adjusted R <sup>2</sup>			
		Birth weight (g)	P value	Social class at birth	P value
<b>Maths scores</b>					
Males:					
Age 7	6072	0.8	<0.001	2.9	<0.001
Age 11	5690	1.4	<0.001	9.9	<0.001
Age 16	4732	1.0	<0.001	11.7	<0.001
Females:					
Age 7	5784	1.0	<0.001	2.7	<0.001
Age 11	5409	1.5	<0.001	10.5	<0.001
Age 16	4553	1.1	<0.001	12.5	<0.001
<b>Adult qualifications</b>					
Males	4307	0.5	<0.001	9.0	<0.001
Females	4518	0.7	<0.001	11.0	<0.001



Maths z scores from ages 7-16 years by birth weight and social class at birth (sexes combined). Class IV and V includes individuals with no male heads of household

## Discussion

### Strengths and limitations

A principal strength of our study is that it uses prospective data from birth onwards in a population based sample that remains broadly representative up to early adulthood.<sup>18</sup> Our study is unique in investigating the combined effects of birth weight and childhood social background on trajectories in cognitive development into adolescence. It has the benefit of a wide spectrum of cognitive tests and educational outcomes collected over 26 years, whereas most studies examine cognitive function at a single age and therefore cannot assess whether the relation with birth weight changes with age. To our knowledge, we have performed the first population based study examining cognition across the range of birth weight with adjustment for gestational age, thereby providing a better measure of fetal growth than indicated by birth weight alone.

Our study has two main limitations. Cognition is notoriously difficult to measure without introducing

cultural biases, and this may affect the estimate of the effect of socioeconomic background. However, it is possible that biases are more limited for the maths tests, which depend less on verbal fluency. The highly skewed distribution of the reading tests made it difficult to construct meaningful trajectories of change with time. A further issue concerns the extent to which birth weight and social class at birth are simplifications of complicated processes occurring before and after birth. We cannot discount the possibility that birth weight reflects biological processes in utero that independently affect postnatal cognitive development.

### Comparison with other studies

Only one study has shown that an association between birth weight and cognition persists with age beyond childhood.<sup>2</sup> The stronger influence of social background shown here is consistent with findings from two Scottish studies and with a Swedish study.<sup>1 9 19</sup>

Our results suggest a cumulative effect of prenatal (birth weight) and postnatal (social class) influences on cognitive development. Although some previous research suggests a modifying effect of the social environment on the association between birth weight and cognition, we found no such interactive effect.<sup>20</sup>

Although the overall effect size of differences in cognitive scores associated with birth weight is small for individuals, the impact in populations may be important. The stronger influence of social factors on cognitive function through to adult life, however, suggests that gains in cognitive development depend more on efforts to redress disadvantages in a child's social environment.

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### What is already known on this topic

Weight at birth is associated with later cognitive development

This is maintained across the range of normal birth weights

### What this study adds

Social class at birth and birth weight have independent effects on maths scores in childhood, but social class at birth explains more of the variation in the scores

The relation between maths scores and birth weight persists across birth weights after adjustment for gestational age, parental education, and other potential confounding factors

Trajectories of maths attainment diverge, with more affluent social groups increasing their relative advantage whereas the effect of birth weight remains constant over time

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## Risk factors for early onset neonatal group B streptococcal sepsis: case-control study

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### Abstract

**Objectives** To quantify risk factors for and the prevalence of early onset group B streptococcal sepsis in neonates in a geographically defined population.

**Design** Cases were collected prospectively for two years from April 1998 and compared with four controls each, matched for time and place of delivery.

**Setting** The former Northern health region of the United Kingdom.

**Participants** Infants infected with group B streptococcus in the first week of life.

**Results** The prevalence of early onset group B streptococcal sepsis was 0.57 per 1000 live births. Premature infants comprised 38% of all cases and 83% of the deaths. Prematurity (odds ratio 10.4, 95% confidence interval 3.9 to 27.6), rupture of the membranes more than 18 hours before delivery (25.8, 10.2 to 64.8), rupture of the membranes before the onset of labour (11.1, 4.8 to 25.9), and intrapartum fever (10.0, 2.4 to 40.8) were significant risk factors for infection. Had the interim recommendations on best practice issued by the Group B Streptococcus Working Group of the Public Health Laboratory Service been uniformly applied to the fetuses alive at the onset of labour, 29 of 37 (78%) might have been given antibiotic prophylaxis during labour. At least 23 of these 29 (79%) could have had antibiotics for four hours or more before delivery. To achieve this, 16% of all women would have been given antibiotics during labour.

**Conclusions** Early onset group B streptococcal sepsis remains an important problem in the United Kingdom. Prevention based on risk factors might reduce the prevalence at the cost of treating many women with risk factors. Using rupture of the membranes before the onset of labour as a risk factor might be expected to improve the success of guidelines for prophylaxis.

### Introduction

Group B streptococcal disease is the leading cause of early onset neonatal sepsis in developed countries.<sup>1</sup> Despite the widespread adoption of preventive strategies in the United States and Australia in recent

years,<sup>2-4</sup> uncertainty prevails as to whether early onset group B streptococcal sepsis is sufficiently common in the United Kingdom to justify widespread prophylaxis.<sup>5</sup> There are few data on the prevalence of early onset sepsis in the United Kingdom and no population based case-control studies on risk factors.

This study aimed to evaluate risk factors for early onset group B streptococcal sepsis by using a case-control design in a geographically defined population while considering preventive strategies already employed.

### Methods

We asked staff from 15 neonatal units throughout the former Northern region to identify neonates of 24 weeks' gestation or more in whom group B streptococcus was isolated from a normally sterile site (blood or cerebrospinal fluid) in the first week of life. We supplemented these data with information from each microbiology department and from the local perinatal mortality survey.

We selected four controls for each case in which the fetus was alive at the onset of labour. Intrapartum stillbirths were included in the case-control study but excluded from the prevalence calculations.

We reviewed obstetric, neonatal, and pathology case notes, paying particular attention to the reason for the onset of labour and the use of antibiotic prophylaxis during labour. Women were considered to have rupture of the membranes before the onset of labour if at least six hours elapsed between rupture of the membranes and the onset of regular uterine contractions.

A standardised questionnaire was sent to the clinical directors of obstetrics and senior clinical midwives at each of the region's 15 maternity units to identify written guidelines on the indications for and the use of antibiotic prophylaxis during labour, and to provide information on how often these guidelines were implemented in practice.

### Results

Thirty six liveborn babies developed group B streptococcal sepsis in the first week of life. As 62 786