School performance at age 7 years in late preterm and early term birth: a cohort study

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ABSTRACT

Objective To investigate the effect of gestational age, particularly late preterm birth (34–36 weeks gestation) and early term birth (37–38 weeks gestation) on school performance at age 7 years.

Design Population-based prospective UK Millennium Cohort Study, consisting of linked educational data on 6031 children.

Methods School performance was investigated using the statutory Key Stage 1 (KS1) teacher assessments performed in the third school year in England. The primary outcome was not achieving the expected level (≥level 2) of general performance in all three key subjects (reading, writing and mathematics). Other outcomes investigated subject-specific performance and high academic performance (level 3).

Results 18% of full-term children performed below the expected KS1 general level, and risk of poor performance increased with prematurity: compared to children born at full-term, there was a statistically significant increased risk of poor performance in those born very preterm (<32 weeks gestation, adjusted RR 1.78, 95% CI 1.24 to 2.54), moderately preterm (32–33 weeks gestation, adjusted RR 1.71, 95% CI 1.15 to 2.54) and late preterm (34–36 weeks gestation, adjusted RR 1.36, 95% CI 1.09 to 1.68). Early term children performed statistically significantly worse in 4 out of 5 individual subject domains than full-term children, but not in the primary outcome (adjusted RR 1.07, 95% CI 0.94 to 1.23).

Conclusions Late preterm, and to a lesser extent, early term birth negatively impact on academic outcomes at 7 years as measured by KS1 assessments.

What is already known on this topic

Delivery before 39 weeks gestation increases the risk of cognitive problems. School performance in late preterm and early term children remains under-researched.

What this study adds

Late preterm and, to a lesser extent, early term delivery is associated with an increased risk of poorer school performance at 7 years.

INTRODUCTION

Late preterm (34–36 weeks gestation) and early term (37–38 weeks gestation) birth is common and increasing in incidence worldwide.[1] For example, these groups comprise 5% and 18% of all live births in England, respectively.[2] Despite the large proportion of late preterm and early term births, there is a paucity of prospective research into their long-term outcomes.

The associations between extreme preterm birth (<28 weeks gestation) and poorer cognitive outcomes and lower levels of academic attainment are well established.[3 4] Recent studies suggest that children born moderately/late preterm and early term have an increased risk of poorer health, cognitive development and school performance.[5–8] A national English study of children in their first year of school, demonstrated that late preterm and early term children attain lower performance compared to their full-term peers.[9] Given there are many important determinants of school performance, this research was undertaken to track the academic performance trajectory of children born at different gestational ages through key developmental stages, to determine whether the academic performance gap identified at 5 years persists at 7 years of age in this cohort. School performance by 7 years is an important outcome to assess because it is strongly associated with future qualifications, socioeconomic status and health.[10–12]

Gestational age in weeks was grouped into categories defined by the American Congress of Obstetricians and Gynecologists (full-term 39–41 weeks gestation, early term 37–38 weeks gestation, late preterm 34–36 weeks gestation, moderately preterm 32–33 weeks gestation, very preterm <32 weeks gestation).[13] Measuring the spectrum of gestational ages enables investigation of a dose-response association between gestation and school performance.

METHODS

Millennium Cohort Study

The Millennium Cohort Study (MCS) is a UK nationally representative longitudinal study of 18 818 children born in 2000–2001.[14] Participants were randomly selected from the Child Benefit Records, a database registering >98% of children in the UK and contacted at 9 months of age for the first survey.[15] There was a deliberate oversampling of areas with higher proportions of ethnic minorities and social disadvantage to enable sufficient representation of these populations. Surveys were performed at 9 months, 3, 5 and 7 years of age, collecting a wide range of demographic and health data, and linking consented education and health information from other sources.[14 15]

Linked

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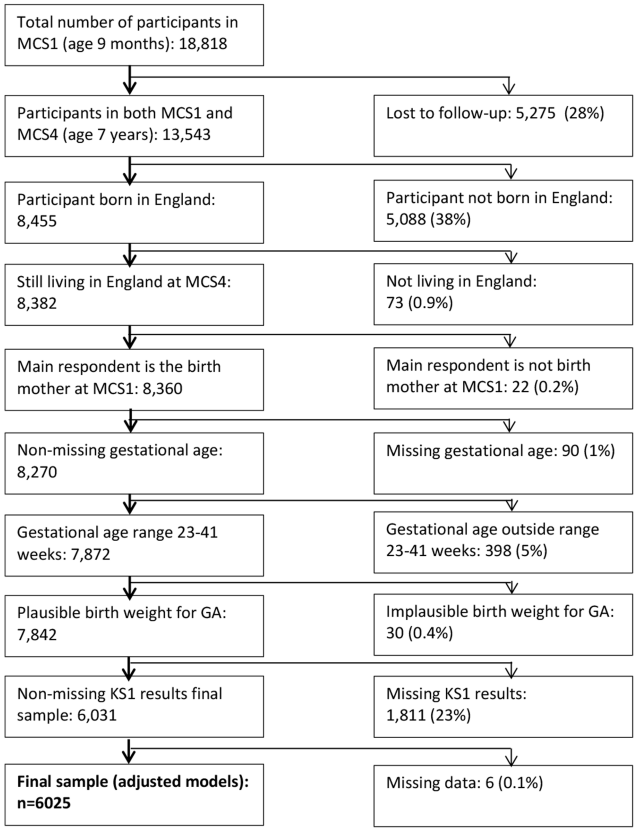

Figure 1 Flowchart showing the number of eligible children in the final study population. Implausible weight for gestational age was defined using the method described in Bonellie *et al*[36] GA, gestational age, KS1: Key Stage 1; MCS, Millennium Cohort Study.

Gestational age

Gestational age was derived from the mother's report of the expected due date in weeks taken at the 9-month survey, which has been shown to have high agreement with routine hospital records except for >42 weeks gestation.[16] The post-term group was excluded from the analysis due to potential misclassification and differences in causal pathways leading to post-term compared to preterm birth.

School performance using Key Stage 1

In England, all state-funded and some private schools progress through the national curriculum comprising of four 'key stages' which begin in year 1 (age 5–6 years) and are completed by the end of year 11.[17] Key Stage 1 (KS1) covers coursework completed between ages 5–7 years in five key domains: reading, writing, speaking and listening, mathematics and science. The KS1 statutory assessments comprise teacher evaluations of the student's academic achievement throughout the school year in each domain according to uniform criteria, aided by standardised KS1 tests in most subject areas.[18] At KS1, children generally perform between level 1 (below expected level) to level 3 (considerably above the expected level), with adequate performance categorised as achieving level 2 or above.[18] For consenting MCS parents, the KS1 results were obtained from the Department of Education's National Pupil Database.

Exclusions and missing data

This study included MCS families who responded at 9 months and 7 years of age with known gestational age, who were born and attending school in England (figure 1). Of the 18 818 children recruited at age 9 months, 13 543(72%) responded to the survey at 7 years; 62% of these children were living in England. Children were also excluded if the mother was not the main respondent, or gestational age was unknown, implausible for birth weight or below 23 weeks or above 42 weeks. 94% of eligible MCS participants had parental consent for record linkage of KS1 results and 77% were successfully linked. This resulted in a total study population of 6031 children.

The most common sources of missing data were from study attrition (5275 (28%) at 7 years which were accounted for using

Table 1 Number of children (weighted percentage) with KS1 missing according to selected factors, overall and by gestational age in the Millennium Cohort Study children in England

Variable	Characteristic	Total (n=7842) (%)	Very/moderately preterm (<34 weeks) n=183 (%)	Late preterm (34–36 weeks) n=469 (%)	Early term (37–38 weeks) n=1632 (%)	Full term (39–41 weeks) n=5558 (%)
Missing KS1 results (%)		1811 (22)	47 (24)	109 (23)	374 (23)	1281 (22)
Maternal birth country	UK	1206 (20)	35 (22)	78 (21)	246 (20)	847 (19)
Education level/qualification	Higher: tertiary (NVQ 4/5)	630 (25)	19 (30)	24 (18)	122 (26)	465 (25)
	Medium: high school (NVQ 3)	229 (21)	5 (34)	14 (20)	51 (25)	159 (20)
	Lower: left 16 years (NVQ 1/2)	535 (18)	15 (19)	43 (20)	121 (19)	356 (17)
	No formal/other	415 (29)	8 (19)	28 (42)	80 (26)	299 (30)
Social class	High: manager/professional	546 (24)	15 (29)	23 (18)	105 (25)	403 (25)
	Intermediate	317 (19)	9 (22)	17 (17)	74 (21)	217 (19)
	Low: routine/semi routine	617 (20)	9 (12)	48 (27)	136 (22)	424 (19)
	Never worked	331 (33)	14 (61)	21 (34)	59 (27)	237 (34)
Ethnicity	White	1147 (20)	31 (22)	74 (22)	239 (21)	803 (19)
	Non-white	662 (36)	16 (32)	35 (28)	135 (31)	476 (39)
Health rating parental report	Excellent	1005 (21)	26 (30)	48 (19)	219 (22)	712 (21)
	Very good	504 (23)	11 (19)	39 (26)	91 (23)	363 (22)
	Good	203 (24)	6 (16)	13 (26)	40 (22)	144 (25)
	Fair or poor	63 (23)	2 (8)	7 (29)	14 (21)	40 (24)
Longstanding limiting illness		140 (26)	7 (23)	11 (27)	29 (27)	93 (26)
3+ hospital admissions		77 (17)	7 (14)	9 (22)	11 (10)	50 (19)

All percentages are weighted.
KS1, Key Stage 1; NVQ, National Vocational Qualification.

non-response weights[19]) and missing KS1 results (1811 (23% unweighted) of eligible participants). Table 1 shows selected demographic factors of children with missing KS1 results. The percentage of missing KS1 results were similar among all gestational age groups (21–27%). Missing KS1 results were more common in children with non-white ethnicity, single-parent households, and mothers who had never worked.

Statistical methods

KS1 results were converted into binary outcomes with adequate performance defined as level 2 or 3, and below the expected level as level 1 or below. The proportion of children performing below expected levels for each outcome was compared in each gestational age group against the full-term reference group. Children who attained level 2 or above in reading, writing and mathematics were categorised as achieving adequate general school performance,[17] and the primary outcome was defined as not having reached this level. The secondary outcome examined the proportion of children performing below the expected level within individual subjects. The tertiary outcome was the proportion of children who were categorised as 'considerably above average' (level 3) generally and in specific subjects.

As study outcomes were common, risk ratios were estimated (rather than ORs) using modified Poisson regression to adjust for potential confounders.[20] The child's sex and age within the school year (oldest—born September to December; middle—born January to April; youngest—born May to August) were adjusted for in all models. For children born between May and August 2001, who were also born before full-term, we also assessed whether they would have been placed in the following school year for corrected age. While the overall number of children who fell into this group was small (53 out of 6031), it affected significant numbers of children born very preterm/moderately preterm (25 out of 136; 18%) or born late preterm (28 out of 360; 8%).

Other variables likely to affect school performance were adjusted for if they were independently associated with the

Table 2 Descriptive characteristics according to gestational age in Millennium Cohort Study children in England

Variable	Characteristic	Total n=6031 (%)	Very preterm (<32 weeks) n=69 (%)	Moderately preterm (32–33 weeks) n=67 (%)	Late preterm (34–36 weeks) n=360 (%)	Early term (37–38 weeks) n=1258 (%)	Full term (39–41 weeks) n=4277 (%)
Maternal characteristics							
UK-born		4904 (85)	55 (84)	56 (89)	309 (88)	1012 (84)	3472 (85)
Marital status	Married	3823 (60)	39 (52)	41 (64)	213 (56)	833 (62)	2697 (60)
	De facto	1508 (27)	19 (30)	18 (25)	104 (31)	282 (25)	1085 (27)
	Single	700 (13)	11 (18)	8 (12)	43 (13)	143 (12)	495 (13)
Education level	Higher	1847 (30)	22 (29)	20 (29)	112 (29)	357 (27)	1336 (30)
	Medium	826 (14)	4 (5)	8 (13)	46 (13)	171 (13)	597 (14)
	Lower	2414 (42)	26 (39)	30 (50)	164 (46)	504 (42)	1690 (41)
	No formal	941 (15)	17 (27)	7 (9)	38 (12)	226 (18)	653 (14)
Socioeconomic status	High	1709 (28)	11 (17)	19 (29)	109 (30)	346 (27)	1224 (28)
	Intermediate	1356 (23)	17 (21)	16 (25)	86 (24)	266 (21)	971 (23)
	Low	2966 (49)	41 (62)	32 (47)	165 (47)	646 (52)	2082 (48)
Ethnicity	White	4964 (86)	50 (80)	53 (88)	295 (86)	965 (83)	3501 (88)
	Non-white	1167 (14)	19 (20)	14 (12)	65 (14)	293 (17)	776 (12)
Languages spoken at home	Only English	5191 (91)	59 (90)	59 (95)	318 (92)	1064 (90)	3691 (92)
	English and other	839 (9)	10 (10)	8 (5)	42 (8)	194 (10)	585 (8)
Pregnancy and perinatal characteristics							
Maternal age, mean (years)		28.7	28.7	29.1	29.2	29.0	28.6
Kept smoking in pregnancy		1142 (21)	20 (31)	12 (17)	79 (23)	252 (23)	779 (21)
Moderate-high alcohol in pregnancy		406 (7)	6 (7)	7 (12)	30 (9)	80 (7)	283 (7)
Male sex		3007 (50)	33 (50)	39 (65)	184 (51)	651 (52)	2100 (49)
Multiple birth		156 (2)	19 (27)	12 (19)	56 (16)	55 (4)	14 (0)
Birth order: firstborn		3574 (59)	37 (53)	29 (40)	205 (59)	810 (63)	2493 (58)
Delivery method	Vaginal	3753 (79)	15 (36)	24 (40)	189 (68)	644 (66)	2881 (85)
	C/section	1022 (21)	30 (64)	27 (60)	96 (32)	341 (34)	528 (15)
Birth weight	Mean (kg)		1.26	2.03	2.57	3.16	3.4
Admission to NICU		535 (9)	62 (94)	56 (82)	136 (38)	110 (8)	171 (4)
Age discharged home, mean (weeks)			8.8	3.0	1.3	0.5	0.4
Breast feeding	Never	1647 (31)	26 (37)	20 (31)	111 (34)	365 (33)	1141 (30)
	0–1 months	1641 (26)	19 (27)	25 (31)	121 (31)	362 (27)	1132 (25)
	2–5 months	1242 (20)	15 (23)	14 (26)	70 (18)	244 (18)	913 (20)
	>6 months	1501 (23)	9 (12)	8 (12)	63 (16)	302 (22)	1137 (25)
Illness limiting activity		383 (6)	13 (18)	10 (15)	32 (8)	83 (7)	245 (6)
3+ hospital admissions		364 (7)	22 (34)	8 (13)	36 (11)	96 (8)	202 (5)
Oldest age group at school*		2076 (34)	15 (22)	28 (40)	115 (32)	449 (36)	1469 (34)
Middle age group at school		1967 (32)	25 (37)	18 (29)	134 (36)	429 (33)	1361 (32)
Youngest age group at school*		1988 (33)	29 (41)	21 (32)	111 (32)	380 (30)	1447 (34)

All percentages are weighted.
*Descriptive data for children categorised as 'oldest', 'middle' and 'youngest' age groups at school are based on birth date in the school year. For children born between May and August 2008, who were also born before full term, we also assessed whether they would have been placed in the following school year for corrected age. However, due to statistical disclosure issues, this is not shown in table 2.
NICU, neonatal intensive care unit.

Table 3 Number (%) and risk ratios for not achieving the expected level in Key Stage 1 according to gestational age in the Millennium Cohort Study

Outcome	Total n=6031 (%)	Very preterm (<32 weeks) n=69 (%)	Moderately preterm (32–33 weeks) n=67 (%)	Late preterm (34–36 weeks) n=360 (%)	Early term (37–38 weeks) n=1258 (%)	Full-term (39–41 weeks) n=4277 (%)
Primary outcome: achieving level 2 (expected) or above in reading, writing and mathematics						
Not achieved	1113 (19)	29 (43)	18 (31)	84 (25)	237 (21)	745 (18)
RR (95% CI) not achieved*		2.41 (1.80 to 3.22)	1.74 (1.06 to 2.85)	1.41 (1.12 to 1.78)	1.18 (1.01 to 1.36)	1
aRR (95% CI) not achieved†		1.78 (1.24 to 2.54)	1.71 (1.15 to 2.54)	1.36 (1.09 to 1.68)	1.07 (0.94 to 1.23)	1
Reading: level 2 (expected) or above						
Not achieved	767 (14)	18 (30)	13 (22)	65 (19)	181 (16)	490 (12)
RR (95% CI) not achieved*		2.49 (1.67 to 3.73)	1.82 (1.03 to 3.20)	1.61 (1.23 to 2.11)	1.36 (1.14 to 1.62)	1
aRR (95% CI) not achieved†		1.84 (1.12 to 3.05)	1.82 (1.12 to 2.98)	1.55 (1.20 to 2.00)	1.22 (1.04 to 1.44)	1
Writing: level 2 (expected) or above						
Not achieved	987 (17)	27 (40)	16 (28)	74 (22)	205 (18)	665 (16)
RR (95% CI) not achieved*		2.54 (1.87 to 3.45)	1.75 (1.07 to 2.85)	1.41 (1.12 to 1.79)	1.13 (0.96 to 1.35)	1
aRR (95% CI) not achieved†		1.82 (1.24 to 2.68)	1.69 (1.14 to 2.50)	1.35 (1.07 to 1.71)	1.03 (0.88 to 1.21)	1
Speaking and listening: level 2 (expected) or above						
Not achieved	623 (11)	20 (29)	11 (15)	47 (12)	150 (14)	395 (9)
RR (95% CI) not achieved*		3.13 (2.15 to 4.56)	1.58 (0.81 to 3.08)	1.33 (0.93 to 1.89)	1.46 (1.19 to 1.79)	1
aRR (95% CI) not achieved†		2.48 (1.63 to 3.78)	1.58 (0.79 to 3.17)	1.36 (0.96 to 1.94)	1.31 (1.08 to 1.60)	1
Mathematics: level 2 (expected) or above						
Not achieved	490 (8)	‡	‡	31 (8)	124 (11)	313 (7)
RR (95% CI) not achieved*		2.65 (1.51 to 4.66)	2.05 (0.94 to 4.43)	1.07 (0.68 to 1.71)	1.50 (1.20 to 1.8)	1
aRR (95% CI) not achieved†		1.89 (0.92 to 3.64)	1.96 (0.97 to 3.99)	1.03 (0.66 to 1.59)	1.38 (1.11 to 1.72)	1
Science: level 2 (expected) or above						
Not achieved	560 (10)	17 (22)	11 (19)	42 (11)	137 (12)	353 (8)
RR (95% CI) not achieved*		2.63 (1.66 to 4.17)	2.21 (1.11 to 4.41)	1.36 (0.95 to 1.95)	1.42 (1.15 to 1.74)	1
aRR (95% CI) not achieved†		1.87 (0.93 to 3.74)	2.25 (1.16 to 4.38)	1.33 (0.91 to 1.94)	1.28 (1.06 to 1.55)	1

All percentages are weighted.
*RR adjusted for multiple birth.
†aRR adjusted for child's sex, child's age in school year taking into account premature children who if born at full term would have been placed in the year below, multiple birth, firstborn status, mother's age, mother's education, mother's social class, marital status, smoking during pregnancy.
‡Due to statistical disclosure guidelines to ensure confidentiality, the raw data for mathematics performance in the very preterm and moderately preterm groups are not reported.

outcome ($p<0.05$): maternal age at delivery, maternal education, maternal socioeconomic status, marital status, multiple births, whether the child was firstborn, and smoking during pregnancy (all collected at 9 months). Six children had missing information on some confounding variables and were excluded from the final adjusted results.

All analyses were performed in Stata and allowed for non-response and the disproportionately stratified and clustered sampling using the 'survey commands'.[21]

The MCS was approved by the Multicentre Research Ethics Committee. Our analysis of KS1 data was performed via the UK Secure Data Service (University of Essex, Colchester, UK) which required strict adherence to confidentiality guidelines. Due to statistical disclosure control guidelines, small sample sizes ($n\leq10$) could not be published, so these have been removed from the data and replaced with an asterisk (*).

RESULTS

Descriptive characteristics

Among the 6031 children included in our study, 21% were born early term and 6% born late preterm, similar to national statistics.[2] table 2 shows descriptive characteristics of the children according to gestational age. As expected, increasing prematurity was associated with multiple birth, low birth weight, neonatal intensive care, and shorter breastfeeding duration. Very preterm children were more likely to have single parents, lower maternal education and employment levels.

Primary outcome

The percentage of MCS children who achieved an adequate level in each KS1 assessment was similar to the national data for England (see online supplementary table), and 18% of full-term children performed below the expected KS1 level. This proportion increased with decreasing gestational age from 21% in early term, 25% in late preterm, 31% in moderately preterm and 43% in very preterm children (table 3). After multivariable adjustment, there was a statistically significant increased risk of poor performance in those born very preterm (adjusted RR1.78, 95% CI 1.24 to 2.54) moderately preterm (adjusted RR 1.71, 95% CI 1.15 to 2.54) and late preterm (adjusted RR 1.36, 95% CI 1.09 to 1.68), but not in those born early term (adjusted RR 1.07, 95% CI 0.94 to 1.23).

Secondary outcome

The gradient of effect between gestational age and KS1 performance was demonstrable particularly in reading and writing (table 3). Early term children had a statistically significantly increased risk of poorer performance compared to full-term children in all subjects except writing with effect sizes (RR) ranging between 1.22–1.38. Late preterm children performed worse than full-term children in reading (adjusted RR 1.55, 95% CI 1.20 to 2.00) and writing (adjusted RR 1.35, 95% CI 1.07 to 1.71) only.

Tertiary outcome

Gestational age was not strongly associated with achieving 'considerably above average' except that very preterm children were

Table 4 Number (%) and risk ratios for achieving 'considerably above expected' level in Key Stage 1 according to gestational age in the Millennium Cohort Study

Outcome	Total n=6031 (%)	Very PT (<32 w) n=69 (%)	Moderately PT (32–33 weeks) n=67 (%)	Late PT (34–36 weeks) n=360 (%)	ET (37–38 weeks) n=1258 (%)	Full-term (39–41 weeks) n=4277 (%)
Achieving level 3 ('considerably above expected') in reading, writing and mathematics						
Achieved	636 (10)	*	*	33 (8)	143 (11)	450 (10)
RR (95% CI) achieved†		0.92 (0.88 to 0.96)	1.02 (0.90 to 1.15)	0.97 (0.94 to 1.01)	1.01 (0.98 to 1.02)	1
aRR (95% CI) achieved‡		0.94 (0.89 to 1.0)	1.01 (0.92 to 1.12)	0.97 (0.94 to 1.00)	1.01 (0.96 to 1.04)	1
Reading: level 3						
Achieved	1701 (27)	11 (20)	11 (15)	95 (26)	343 (26)	1241 (28)
RR (95%CI) achieved†		0.89 (0.78 to 1.03)	0.84 (0.74 to 0.96)	0.96 (0.89 to 1.03)	0.96 (0.92 to 1.0)	1
aRR (95% CI) achieved‡		0.97 (0.83 to 1.14)	0.89 (0.74 to 0.93)	0.97 (0.92 to 1.04)	0.98 (0.94 to 1.02)	1
Writing: level 3						
Achieved	808 (13)	*	*	45 (19)	181 (13)	571 (13)
RR (95% CI) achieved†		0.90 (0.85 to 0.95)	0.99 (0.88 to 1.12)	0.97 (0.93 to 1.01)	1.01 (0.98 to 1.03)	1
aRR (95% CI) achieved‡		0.93 (0.86 to 1.01)	0.98 (0.89 to 1.09)	0.97 (0.94 to 1.01)	1.01 (0.98 to 1.04)	1
Speaking and listening: level 3						
Achieved	1423 (23)	10 (16)	14 (17)	79 (21)	306 (24)	1014 (24)
RR (95% CI) achieved†		0.92 (0.81 to 1.03)	0.93 (0.80 to 1.06)	0.97 (0.91 to 1.03)	1.00 (0.97 to 1.03)	1
aRR (95% CI) achieved‡		0.95 (0.84 to 1.09)	0.91 (0.80 to 1.02)	0.97 (0.92 to 1.03)	1.02 (0.98 to 1.05)	1
Mathematics: level 3						
Achieved	1475 (24)	*	*	82 (22)	316 (24)	1059 (24)
RR (95% CI) achieved†		0.81 (0.75 to 0.89)	0.92 (0.79 to 1.05)	0.97 (0.91 to 1.04)	1.00 (0.96 to 1.04)	1
aRR (95% CI) achieved‡		0.86 (0.78 to 0.94)	0.88 (0.79 to 0.99)	0.97 (0.91 to 1.04)	1.00 (0.96 to 1.04)	1
Science: level 3						
Achieved	1496 (24)	*	*	85 (24)	304 (23)	1085 (25)
RR (95% CI) achieved†		0.89 (0.78 to 1.03)	0.89 (0.78 to 1.03)	0.98 (0.92 to 1.05)	0.98 (0.94 to 1.02)	1
aRR (95% CI) achieved‡		0.96 (0.83 to 1.11)	0.87 (0.78 to 0.98)	1.00 (0.93 to 1.08)	0.99 (0.95 to 1.02)	1

All percentages are weighted.
*Due to statistical disclosure guidelines to ensure confidentiality, the raw data for mathematics performance in the very preterm and moderately preterm groups are not reported.
†RR adjusted for multiple birth.
‡aRR adjusted for child's sex, child's age in school year taking into account premature children who if born at full term would have been placed in the year below, multiple birth, firstborn status, mother's age, mother's education, mother's social class, marital status, smoking during pregnancy.

less likely to perform 'considerably above average' in general KS1 compared to full-term children (adjusted RR 0.92, 95% CI 0.88 to 0.96) (table 4).

DISCUSSION

This study demonstrates that at age 7 years, children born at lower gestations are at increased risk of poorer academic performance than their full-term peers. Children born very preterm were most likely to achieve below the expected level in general KS1, but moderately preterm and late preterm children had a 71% and 36% increased risk respectively. Early term children performed similarly to full-term children in general KS1 measures, however, they performed consistently poorer in all five subject domains except writing. The association between gestational age and school performance appears to follow a sigmoid gradient. Compared to full-term children, very preterm children have the highest risk of poor school performance, which lessens with moderately and late preterm children, and a small effect in early term children. Very preterm children are less likely to perform considerably above average, but the other gestational age groups are not strongly associated with this outcome. Although the adverse effects of late preterm and early term birth are small in comparison with factors such as gender, parental education and school attendance,[9 11 22] they may augment these other risk factors for poor school performance. For example, 24% of boys and 15% of girls performed below the expected level in KS1. The additional effect of late preterm delivery (adjusted RR 1.36, 95% CI 1.09 to 1.68) would increase these risks to 33% and 20%, respectively.

The strengths of this study are that it examines a large, nationally representative cohort which has sufficient power to analyse the full range of gestational ages. The KS1 assessment is statutory, validated and based on subjective (teacher observation) and objective (test) components which together provide a measure of the child's performance throughout the year. This study also provides subject-specific data, supporting previous studies on the association between gestational age and school performance,[5 23] and thus enabling identification of specific skill-sets which may be influenced by gestational age.

The main limitation of this analysis was missing data, with 28% study attrition and 23% missing KS1 results. Study attrition was addressed using non-response weights. The children with missing KS1 results were more likely to be very preterm, have higher rates of poorer health, special educational needs and lower socioeconomic status. Therefore, the true effect of gestational age on academic performance may be underestimated due to under-representation of these children.

Literature on the association between late preterm and early term birth and school performance is mixed, with some studies reporting small adverse effects,[7 23 24] others reporting language difficulties only[25 26] and some studies finding no effect.[27 28] Our findings are consistent with most large cohort studies, demonstrating that decreasing gestational age is associated with a small increased risk in most general and subject-specific measures.[9 23 24 29]

This study follows a preceding analysis of school performance in the MCS cohort at age 5 years.[9] Quigley's study demonstrated that early term and late preterm children had increased difficulties in 'communication, language and literacy' and 'mathematical development' compared to full-term children.[9] These groups continue to have poorer performance in reading, writing (late preterm only) and mathematics (early term, but not late preterm) at age 7 years. Providing that there are a multitude of factors which determine school performance, it is striking that being born just a few weeks early continues to be associated with academic performance. These findings are supported by another UK study of KS1 performance, which found moderate to late preterm children (32–36 weeks gestation) were less likely to be successful in achieving level 2 or above in reading, writing and mathematics.[5]

The mechanisms underlying this association of decreasing gestational age and poorer school performance are likely to be multifactorial. Considerable brain growth occurs during the final trimester, with the brain at 34 and 36 weeks gestation weighing only 65% and 80% of the full-term brain, respectively.[30] Foetal brain development is complex and occurs in highly specific orders and timeframes. Even small disruptions caused by a shortened gestation may have long-term ramifications.

Physiological immaturity of the late preterm or early term infant may also be another explanatory mechanism. Delivery prior to full-term increases the stress-mediated response, and predisposes to temperature and blood sugar instability which may affect brain development.[31 32]

Another potential explanation is the role of behaviour and attention in school performance. Research suggests that late preterm and early term children have higher rates of attention-deficit hyperactivity disorder[33] and problematic behaviours in teacher and parent rating scales.[7 34]

Our results have identified that late preterm and early term birth are associated with an increased risk of poorer school performance. These risks may be inherent to preterm birth, or reflective of the maternal and foetal conditions which predispose to birth before full term. Nonetheless, these risks should be considered in decision making of deliveries prior to full-term. Children born after 33 weeks gestation do not receive routine neurodevelopmental follow-up, but increased vigilance of the potential risks associated with late preterm/early term birth and academic underperformance may enable earlier identification and management of potential school difficulties particularly if other risk factors are present. Although individual risks are small, late preterm and early term children comprise approximately one quarter of all live births, and thus public health implications may be substantial through potentially increased special educational needs, lower educational attainment and lower future income.[8 35]

Future research is required to discern performance trajectories of infants born late preterm and early term, identify high-risk subgroups, and develop effective monitoring and intervention strategies to improve school performance in children born prior to full term.

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Competing interests None.

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Online Supplement Table: *Key Stage 1 results for children at school in England: Comparison of MCS data with national statistics of achieving adequate level (level 2 or above) per subject*

KS1 assessment	**% of children performing adequately in this assessment**	
	MCS %	**England % ***
General KS1	81	Not presented in national statistics
Reading	86	84
Writing	83	80
Speaking and listening	89	87
Mathematics	92	90
Science	90	89

** Source: National Curriculum Assessments at KS1 in England, 2008, Department for Children, Schools and Families*