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Academic Achievement Varies With Gestational Age Among Children Born at Term

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KEY WORDS

gestational age, developmental outcomes, risk factors, school performance, reading achievement

ABBREVIATIONS

BOE—Board of Education
CTB—California Testing Bureau
DOHMH—Department of Health and Mental Hygiene
NYC—New York City

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WHAT'S KNOWN ON THIS SUBJECT: Late preterm infants are at risk for a variety of developmental impairments; however, little is known about developmental differences among children born within the term range of 37 to 41 weeks' gestation.

WHAT THIS STUDY ADDS: This study links comprehensive birth record data from 128 050 term births to children's school records 8 years later. Analyses establish that, even among the "normal term" range, gestational age is an important independent predictor of academic achievement.

abstract

NIH

OBJECTIVE: The goal of this study was to examine the degree to which children born within the "normal term" range of 37 to 41 weeks' gestation vary in terms of school achievement.

METHODS: This study analyzed data from 128 050 singleton births born between 37 and 41 weeks' gestation in a large US city. Data were extracted from city birth records to assess a number of obstetric, social, and economic variables, at both the individual and community levels. Birth data were then matched with public school records of standardized city-wide third-grade reading and math tests. Specifically, we assessed (1) whether children born within the normal term range of 37 to 41 weeks' gestation show differences in reading and/or math ability 8 years later as a function of gestational age, and (2) the degree to which a wide range of individual- and community-level social and biological factors mediate this effect.

RESULTS: Analyses revealed that gestational age within the normal term range was significantly and positively related to reading and math scores in third grade, with achievement scores for children born at 37 and 38 weeks significantly lower than those for children born at 39, 40, or 41 weeks. This effect was independent of birth weight, as well as a number of other obstetric, social, and economic factors.

CONCLUSIONS: Earlier normal term birth may be a characteristic considered by researchers, clinicians, and parents to help identify children who may be at risk for poorer school performance. *Pediatrics* 2012;130:e257–e264

The developmental risks of early preterm birth are well established. Recently it has been recognized that even late preterm infants, born from 34 to 36 weeks' gestation, are at risk for adverse developmental outcomes.[1–9] Less clear, however, is the degree to which developmental risk varies with gestational age among infants born "at term," between 37 and 41 weeks' gestation. Brain development continues throughout gestation, including rapid growth in the final month of pregnancy.[10,11] Yet children born from 37 to 41 weeks' gestation are frequently combined into a single reference group in studies investigating cognitive outcomes.[1,3–6,8,9,12–14] It is unclear whether this cut point of 37 weeks is appropriate,[12] and the degree of heterogeneity in academic achievement across this 5-week period of "normal" gestation remains largely uninvestigated.

This study uses a retrospective cohort design to examine a large sample of urban American children born across the range of term gestation, to investigate whether earlier gestational age at birth confers a continuum of risk for poor academic achievement. Access to a large data set linking comprehensive birth records to school records affords the unique opportunity to explore a wide range of individual- and community-level social and biological factors that may mediate this effect.

METHODS

Population

The study sample consists of all singleton births born to mothers residing in New York City (NYC) from 1988 to 1992 who (1) were between 37 and 41 weeks' gestation, (2) subsequently enrolled in third grade in NYC public schools from 1996 to 2000, and (3) for whom third-grade standardized reading or math test scores were available. Birth records from the NYC Department of Health and Mental Hygiene (DOHMH) were matched to NYC Board of Education (BOE) records, as described previously.[15,16] Briefly, a data file from the DOHMH, containing the full name, birth date, and gender of each child was sent to the BOE to be matched against a file containing information on all children who have attended NYC public schools. To be considered a match, the DOHMH and BOE records were required to be identical with respect to the first 6 characters of both the first and last name; the month, day, and year of birth; and gender. There were 150 589 children whose data were successfully matched in this manner. Additional criteria for inclusion in the study included having valid data for all 20 demographic and risk variables described in the next section, membership in 1 of 4 major ethnic groups (Asian American, non-Hispanic African American, non-Hispanic white, Hispanic), and delivery within 1 of the 5 NYC boroughs. In all, 128 050 (85.0%) met these criteria and also had available reading test data. A small number of these children did not have available math test data, and thus analyses involving math scores included a slightly smaller sample of 127 532 children (84.7% of the full matched sample). After matching, the data were de-identified by the BOE and made available for analysis, as part of a protocol approved by the DOHMH, BOE, and the Columbia University Institutional Review Board.

Specification of Variables

The outcomes of interest were the child's scores on the California Testing Bureau (CTB) Achievement Test, a city-wide proprietary standardized test adapted from the Terra Nova test series specifically for the NYC BOE by CTB/McGraw-Hill. The standardized reading test measured students' ability to understand continuous prose, focusing on evaluating meaning of written text.[17] The standardized math test measured basic mathematical skills, such as computation and estimation.[18] The CTB was administered to all NYC public school third-graders from 1996 to 2000. Because the scale of the CTB changed between 1996 and 1998, scores for each year were converted to T scores ($M = 50$; $SD = 10$) based on city-wide means and SDs provided by the BOE.[15]

NYC hospitals abstract information from the medical records of all deliveries, which is reported to the DOHMH. We derived 20 variables representing obstetric, individual-level, and community-level characteristics, many of which confer risk for poor school performance, as suggested by previous studies.[15,16,19]

Obstetric characteristics included gestational week at birth (defined by the start of the week, ie, from 37 weeks, 0 days, to 37 weeks, 6 days), birth weight, cesarean delivery, parity, low prenatal care ($\leq$6 prenatal visits), and advanced maternal age ($\geq$35 years).

Individual-level characteristics included years of maternal education, Medicaid status, teenage motherhood, marital status, mother's nativity (foreign-born), history of maternal substance abuse (including alcohol), history of maternal smoking in pregnancy, child gender, and mother's race/ethnicity (African American non-Hispanic, white non-Hispanic, Asian, and Hispanic).

Community-level characteristics were derived from US Census and NYC Department of Criminal Justice data, to characterize the neighborhood in which the mother resided at the time of delivery. The unit of analysis for community-level variables was the NYC Health Area, as defined by the DOHMH. Each Health Area contains ~20 000 people and is an aggregate of 4 to 6 contiguous US census tracts. Community-level variables included percentage of residents living below the federal poverty level, percentage who immigrated within the previous 5 years, percentage of housing units with $>$1 person per room, percentage of residents with stable housing for $\geq$5 years, and neighborhood homicide rate.

Data Analysis

We first assessed whether, within the "normal term" gestational range, there existed a significant relation between weeks of gestation at birth and third-grade reading and/or math scores. Relative risk of reading and math deficits were then calculated for infants born at each gestational week relative to the reference of 41 weeks. Next, as the relationship between gestational age and school achievement scores may be confounded by birth weight, the models were expanded to include birth weight. Last, we examined the effects of all individual, community, and obstetric characteristics described previously.

TABLE 1 Summary Statistics for All Risk Factors (n = 128 050)

Variable Description	Mean (SD) or Count/%
Obstetric factors	
Gestational wk	39.25 (1.2)
37	12 184/9.52
38	23 365/18.25
39	35 197/27.49
40	35 213/27.50
41	22 091/17.25
Birth weight, g	3328 (485)
Cesarean delivery	19 624/15.3
Parity	1.94 (1.2)
Low or no prenatal care	30 982/24.2
Advanced maternal age (≥35 y)	14 711/11.5
Individual-level factors	
Child gender	
Male	61 775/48.2
Female	66 275/51.8
Race/Ethnicity	
White non-Hispanic	34 950/27.3
African American non-Hispanic	42 875/33.5
Asian	11 847/9.3
Hispanic	38 378/30.0
Maternal education, y	12.0 (2.4)
Medicaid	48 113/37.6
Teenage mother	14 409/11.3
Mother unmarried	53 991/42.2
Mother foreign-born	62 845/49.1
Maternal substance use during pregnancy (including alcohol)	3295/2.6
Maternal smoking during pregnancy	6723/5.3
Community-level factors (mean % of community population)	
Percent below poverty level	22.7 (13.8)
Percent recent immigrants (within previous 5 y)	6.0 (3.8)
Percent living in crowded housing units	17.2 (8.4)
Percent living in same house ≥5 y before census	58.5 (5.8)
Homicide rate (per 10 000 residents)	1.4 (1.2)

Means and SDs are shown for continuous variables. Counts and percentages are shown for dichotomous variables. Mean percentages are shown for community-level variables.

RESULTS

Table 1 describes the sample with respect to all obstetric, individual, and community-level factors. These summary statistics reflect the striking diversity of the NYC population, with a high proportion of mothers in various risk groups.

Reading and math scores were, unsurprisingly, highly correlated (R = 0.694; $P < .001$). Initial analyses consisted of 2 one-way analyses of variance, examining the effect of gestational week at birth on third-grade reading and math scores, respectively. Gestational age within the normal term range was significantly and positively related to both third-grade reading score (F [4, 128 045] = 21.635; $P < 7.2 \times 10^{-18}$) and third-grade math score (F [4, 127 527] = 27.904; $P < 3.4 \times 10^{-23}$), with scores improving with each week of gestation, as shown in Figs 1 and 2. Table 2 shows that both reading and math scores for children born at 37 and 38 weeks were significantly lower than those of children born at any other week, adjusting for multiple comparisons by using the Bonferroni method. Differences among children born at 39, 40, or 41 weeks' gestation were not significant (although in all cases, the nonsignificant trend was for greater reading and math scores at later gestational ages).

We next assessed, for each week of gestation, the relative risk of mild, moderate, and severe reading and math impairments, defined as at least 1.0, 1.5, and 2.0 SDs below the population average, respectively. Table 3 shows that relative to children born at 41 weeks' gestation, children born at 37 weeks have a 14% greater risk of having at least mild reading impairment, a 23% increased risk of having at least moderate reading impairment, and a 33% increased risk of having a severe reading impairment. Children born at 38 weeks' gestation have an 8% increased risk of at least mild reading impairment and a 13% increased risk of at least moderate reading impairment. Table 4 shows that children born at 37 weeks have a 16% greater risk of having at least mild math impairment and a 19% increased risk of having at least moderate math impairment. Children born at 38 weeks have a 12% increased risk of having at least mild math impairment.

Because of the association between birth weight and gestational age,[14,20] birth weight was introduced into the models. Both birth weight and gestational age were significant, independent predictors of reading score (birth weight: β = 0.062; $P < .0001$; gestational age: β = 0.011; $P < .0001$) and math score (birth weight: β = 0.092; $P < .0001$; gestational age: β = 0.007; $P < .012$).

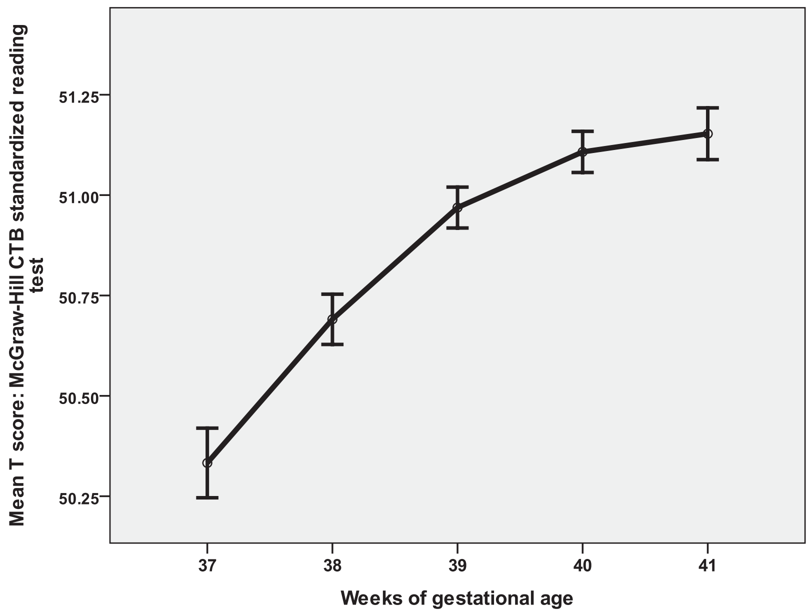

FIGURE 1
Gestational week at birth was significantly and positively associated with reading score: (F [4, 128 045] = 21.635; $P < 7.2 \times 10^{-18}$). Error bars represent ±1 SE.

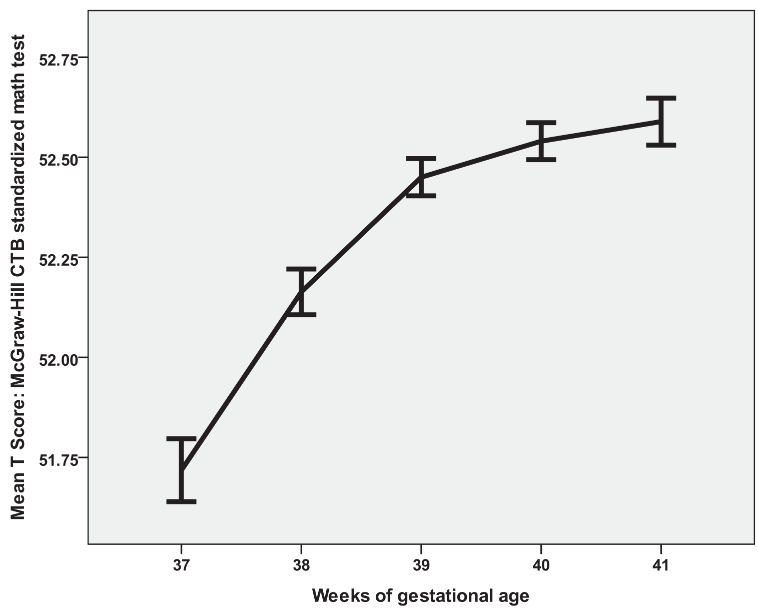

FIGURE 2
Gestational week at birth was significantly and positively associated with math score: (F [4, 127 527] = 27.904; $P < 3.4 \times 10^{-23}$). Error bars represent ±1 SE.

To elucidate the possible mechanisms mediating the effect of gestational age on school achievement, we next developed 3 general linear models. In each model, both reading and math scores were included as dependent variables. The 3 models incorporated, respectively, the obstetric, individual-level, and community-level characteristics described previously. Most of these variables were highly significant predictors of third-grade reading and math scores. Table 5 shows that gestational age at birth continues to be a significant predictor of school achievement, even after adjusting for these obstetric, individual-level, and community-level characteristics.

DISCUSSION

The American Academy of Pediatrics and the National Institute of Child Health and Human Development recently classified infants born from 34 to 36 weeks' gestation as "late preterm,"[21] signaling an awareness that these infants are at increased risk for a number of developmental outcomes, including lower IQ,[1,2] developmental delay,[3,4] deficits in visuospatial and executive function skills,[5] reading difficulties,[6,7] behavioral disorders,[8] attention-deficit/hyperactivity disorder,[9] and even mental retardation[3,8] and cerebral palsy.[3,8] Surprisingly, far less is known about the degree to which earlier gestational age confers risk among infants born at term, from 37 to 41 weeks' gestation.[7,22–24] The brain continues to grow rapidly during this time, with a nearly 50% increase in cortical gray matter,[10] a nearly threefold increase in myelinated white matter,[10] and increasing neuronal and gyral differentiation.[11] Further, among term infants born from 37 to 41 weeks, later gestational age is associated with greater gray matter density in middle childhood in bilateral superior and middle temporal gyri, and the left parietal lobe.[25] These regions have been associated with reading[26] and math performance,[27] respectively.

Based on this reasoning, we hypothesized that the commonly held belief that children born between 37 and 41 weeks' gestation will tend to develop "normally" without any difference as a function of the particular week of gestation may not be accurate.

This study provides support for this hypothesis. Among a sample of 128 050 children born at term, we found a significant, positive relationship between gestational age at birth and third-grade

TABLE 2 Difference in Reading and Math Scores by Week of Gestation[a]

Week Gestation (I)	Week Comparison (J)	Reading Scores			Math Scores		
		Mean Difference (I − J)	SE	*P*	Mean Difference (I − J)	SE	*P*
37	38	−0.358	0.107	.001[b]	−0.445	0.097	<.0001[b]
	39	−0.636	0.101	<.0001[b]	−0.732	0.092	<.0001[b]
	40	−0.775	0.101	<.0001[b]	−0.822	0.092	<.0001[b]
	41	−0.820	0.109	<.0001[b]	−0.871	0.098	<.0001[b]
38	39	−0.278	0.081	.001[b]	−0.287	0.073	<.0001[b]
	40	−0.417	0.081	<.0001[b]	−0.377	0.073	<.0001[b]
	41	−0.462	0.090	<.0001[b]	−0.426	0.082	<.0001[b]
39	40	−0.137	0.072	.055	−0.090	0.066	.17
	41	−0.184	0.082	.025	−0.139	0.075	.063
40	41	−0.045	0.082	.582	−0.049	0.075	.513

Children born at 37 and 38 weeks' gestation score significantly lower on reading and math achievement tests than children born at every other week.

[a] α set at 0.0025 to control for multiple comparisons (eg, 0.05/20).

[b] Significant when using Bonferroni correction for multiple comparisons.

school achievement. Each week of increased gestation from 37 to 41 weeks showed an added benefit in both reading and math scores. Further, children born at 37 or 38 weeks performed significantly worse than children born at 39, 40, or 41 weeks, and have a significantly increased relative risk of impaired reading and math skills on standardized school achievement tests.

These findings have important implications in considering the definition of "term." The intrauterine environment likely supports typical brain development, which may be more likely to be disrupted when children are born early, even within the commonly defined period of term gestation. This disruption may affect later academic achievement, as our findings suggest.

The mechanisms underlying the effect of gestational age at birth on school achievement are likely multifactorial. Because of the nature of this remarkable data set, in which birth records containing a large set of variables were matched with corresponding public school records 8 years later, we were able to examine the effects of a number of obstetric, economic, and social characteristics. Indeed, nearly all characteristics assessed were highly significant predictors of third-grade school achievement. Although a broad range of obstetric, individual-level, and community-level socioeconomic and demographic characteristics were considered, the effect of gestational age persisted even when controlling for these potential mediating factors. Future research is necessary to investigate the causal mechanism(s) explaining the relations described here. More specifically, we may ask: Is there a subtle yet meaningful risk of impaired development caused by birth at 37 to 38 weeks, relative to birth in the 39- to 41-week range? Or, is the apparent risk of what might be called "early term birth" (37 to 38 weeks' gestation), seen in Figs 1 and 2, caused by the confounding effects of other unmeasured factors, risks that are themselves associated with both early term birth and school performance?

Regardless of the mechanism, the evidence presented previously suggests that it may be inappropriate to cluster children born between 37 and 41 weeks' gestation together as a single category when considering developmental outcomes. This has several important implications.

From a scientific perspective, the inappropriate grouping of heterogeneous populations may lead to a loss of power when investigating developmental differences. From a clinical perspective, these data suggest that early term birth may be a characteristic by which pediatricians may identify children who may be at risk for poorer school performance. It should also be noted that there is an increasing trend for performing elective early deliveries for nonmedical reasons,[28] contributing in part to the fact that the most common length of gestation for singleton births has shifted from 40 to 39 weeks.[28] Although further research is needed, women or physicians seeking early delivery for social or logistical reasons may wish to consider this finding, particularly before 39 weeks.

TABLE 3 Relative Risk of Mild, Moderate, and Severe Reading Impairment

Gestational Week	Not Impaired, *n* (%)	At Least Mildly Poor Reading, *n* (%)	Relative Risk Mildly Poor Reading (95% CI)	At Least Moderately Poor Reading, *n* (%)	Relative Risk Moderately Poor Reading (95% CI)	Severely Poor Reading, *n* (%)	Relative Risk Severely Poor Reading (95% CI)
37 (*n* = 12 184)	10 749 (88.2)	1436 (11.8)	1.14 (1.07–1.21)	660 (5.4)	1.23(1.12–1.35)	283(2.3)	1.33 (1.14–1.54)
38 (*n* = 23 365)	20 740 (88.8)	2625 (11.2)	1.08 (1.03–1.14)	1169 (5.0)	1.13 (1.04–1.23)	457 (2.0)	1.12 (0.98–1.28)
39 (*n* = 35 197)	31 507 (89.5)	3690 (10.5)	1.011 (0.96–1.06)	1647 (5.2)	1.05 (0.98–1.14)	658 (2.1)	1.06 (0.93–1.20)
40 (*n* = 35 213)	31 535 (89.6)	3678 (10.4)	1.007 (0.96–1.06)	1577 (4.5)	1.01 (0.94–1.09)	641 (1.8)	1.03 (0.91–1.17)
41 (*n* = 22 091)	19 800 (89.6)	2291 (10.4)	n/a	979 (4.4)	n/a	390 (1.8)	n/a

Relative risk of mild, moderate, and severe reading impairment for children born from 37 to 40 weeks' gestation, relative to the reference group of 41 weeks' gestation. Children born at 37 wk are at increased risk for all levels of impairment. Children born at 38 wk are at increased risk for mild and moderate impairment. "Mildly poor reading," "Moderately poor reading," and "Severely poor reading" are defined as scoring at least 1.0, 1.5, or 2.0 SDs below population average, respectively. "Not impaired" is defined as performance better than the mildly impaired group. CI, confidence interval.

TABLE 4 Relative Risk of Mild, Moderate, and Severe Math Impairment

Gestational Week	Not Impaired, *n* (%)	At Least Mildly Poor Math, *n* (%)	Relative Risk Mildly Poor Math (95% CI)	At Least Moderately Poor Math, *n* (%)	Relative Risk Moderately Poor Math (95% CI)	Severely Poor Math, *n* (%)	Relative Risk Severely Poor Math (95% CI)
37 (*n* = 12 119)	11 311 (93.3)	808 (6.7)	1.16 (1.07–1.27)	287 (2.4)	1.19 (1.02–1.38)	130 (1.1)	1.19 (0.95–1.49)
38 (*n* = 23 273)	21 782 (93.6)	1491 (6.4)	1.12 (1.04–1.20)	520 (2.2)	1.11 (0.98–1.27)	242 (1.0)	1.15 (0.95–1.39)
39 (*n* = 35 074)	32 999 (94.1)	2075 (5.9)	1.03 (0.96–1.10)	758 (2.2)	1.07 (0.95–1.21)	349 (1.0)	1.10 (0.92–1.31)
40 (*n* = 35 075)	33 031 (94.2)	2044 (5.8)	1.02 (0.95–1.09)	708 (2.0)	1.00 (0.89–1.13)	308 (0.9)	0.97 (0.81–1.16)
41 (*n* = 21 991)	20 729 (94.3)	1262 (5.7)	n/a	443 (2.0)	n/a	200 (0.9)	n/a

Relative risk of mild, moderate and severe math impairment for children born from 37 to 40 weeks' gestation, relative to the reference group of 41 weeks' gestation. Children born at 37 wk are at increased risk for mild to moderate math impairment. Children born at 38 wk are at increased risk for mild math impairment. "Mildly poor math," "Moderately poor math," and "Severely poor math" are defined as scoring at least 1, 1.5, or 2 SDs below population average, respectively. "Not impaired" is defined as performance better than the mildly impaired group. CI, confidence interval.

TABLE 5 Models of Effects of Gestational Age on School Achievement, Controlling for Obstetric, Individual-Level, and Community-Level Characteristics

	Adjusted Mean Square: Reading	Adjusted Mean Square: Math	F	*P*
Model 1: Obstetric-level characteristics				
Birth weight	34 150	65 439	451.757	<.0001
Cesarean delivery	5215	4009	34.027	<.0001
Parity	208 107	156 073	1343.239	<.0001
Low or no prenatal care	73 186	70 518	539.022	<.0001
Advanced maternal age	115 623	84 422	737.990	<.0001
Gestational wk	204	208	2.916	.020
Model 2: Individual-level characteristics				
Child gender (male)	79 714	4674	1256.990	<.0001
Race/Ethnicity:				
Black Non-Hispanic	239 432	309 123	2553.988	<.0001
Asian	240	60 305	784.791	<.0001
Hispanic	188 223	180 582	1612.586	<.0001
Maternal education	452 097	329 967	3338.661	<.0001
Medicaid	25 579	13 291	168.999	<.0001
Teenage mother	357	1248	10.578	<.0001
Mother unmarried	39 845	38 738	344.306	<.0001
Mother foreign-born	2281	363	44.988	<.0001
Maternal substance use during pregnancy (including alcohol)	0	17	0.288	.749
Maternal smoking during pregnancy	3102	2664	24.864	<.0001
Gestational wk	116	169	2.734	.027
Model 3: Community-level characteristics				
Neighborhood poverty, %	108 295	64 987	679.034	<.0001
Neighborhood foreign born, %	6105	34 422	287.809	<.0001
Neighborhood housing crowding, %	39 341	50 371	376.147	<.0001
Neighborhood housing stability, %	156	2196	39.765	<.0001
Neighborhood homicide rate (per 10 000 residents)	39 070	61 566	448.677	<.0001
Gestational wk	841	830	0.016	<.0001

Three multivariate general linear models were constructed including both math and reading scores as dependent variables. Independent variables included obstetric characteristics in model 1; individual-level characteristics in model 2; and community-level characteristics in model 3. Most of these characteristics were highly significant predictors of third-grade school achievement. In each case, after adjusting for these potential mediators, gestational age at birth significantly predicted achievement test scores. Significance levels of multivariate tests are reported by using Roy's Largest Root. Follow-up univariate tests revealed that, when controlling for other obstetric factors, gestational week was a significant predictor of math ($F = 2.870$; $P < .022$) but not reading ($F = 2.310$; $P < .055$). Similar univariate results were found when controlling for individual-level characteristics (math: $F = 2.715$; $P < .028$); reading: $F = 1.468$; $P < .209$). When controlling for community-level characteristics, univariate tests showed that gestational week was a significant predictor of both math ($F = 12.052$; $P < .0001$) and reading ($F = 9.891$; $P < .0001$).

This study has several limitations. Notably, although gestational age from 37 to 41 weeks showed a graded relationship with third-grade reading and math scores, the effect size was small. Many other social, economic, and obstetric factors predict academic achievement in elementary school; however, the goal of this study was not to provide a comprehensive model accounting for the largest possible amount of variance in school achievement. Rather, we asked specifically whether there would be a detectable difference in reading and math achievement among children born at different weeks of gestation within the commonly accepted normal range, and we have answered that question in the affirmative. Given that so many other powerful factors affect school performance in the years between birth and third grade, the fact that, 8 years later, we still observe statistically significant differences between children born only 1 week apart (eg, 38 vs 39 weeks), within the normal range of gestational ages, is noteworthy. Further, although the average difference in score by gestational week was small, the finding of a significantly increased relative risk for reading and math impairment renders these data clinically relevant. For example, children born at 37 weeks' gestation were found to be 33% more likely to experience a severe reading deficit (defined here as 2 SDs below the mean) relative to children born at 41 weeks' gestation. Of course, this study's large sample size provided considerable statistical power. Thus, although smaller increases in relative risk were also detectable for more mild deficits, the degree to which some of these more moderate increases in risk should translate to effects on clinical decision-making is not yet clear.

Another limitation of the study may be restricted generalizability. The sample was obtained from birth records in a large American city, consisting of a relatively high proportion of minority and disadvantaged families. The causes underlying early term birth in this population (including whether early deliveries were performed on an elective basis) are unknown. However, other recent population-based studies also indicate a negative impact on cognition from birth at 37 to 38 weeks relative to later birth in Denmark,[7] Belarus,[22] Switzerland,[24] and Scotland,[23] suggesting that the effect reported here may indeed be robust.

This study involved secondary data in which the primary measures were not obtained by using rigorous research methods. Birth record data were abstracted by hospitals, and more precise information, such as whether gestational age was obtained by dates or ultrasound, is not available. Additionally, it is likely that some gestational ages may have been incorrectly assigned prenatally or in the delivery room. Factors that could further illuminate underlying mechanisms, such as the percentage of elective versus emergent deliveries, are unknown. The particular outcome measures used do not reflect all aspects of reading or math achievement, and effects on other skills (writing, mathematical reasoning) are unknown. Indeed, later editions of these standardized tests have subsequently been updated to reflect more current educational testing practices, focusing more, for instance, on abstract reasoning and solving real-life problems.[18]

Further, third-grade children taking tests in a classroom are distractible and not necessarily motivated to perform well, and differences between schools, classes, and testing environments may create variability in test scores unrelated to true reading and math ability. These factors, together with other unmeasured factors between birth and age 8, contribute to measurement error, and therefore reduce effect size. So although the error measurement inherent in the use of public records is a necessary limitation in research of this type,[29–31] we would argue that because of the effect-attenuation of this error measurement, the negative impact of early term birth on academic achievement is likely greater than the small but significant effect we report here.

CONCLUSIONS

Increased gestational age at birth has a positive association with third-grade reading and math scores among children born in the 37- to 41-week range, commonly defined as term gestation. From a public health perspective, this may have important consequences, particularly in the realm of identifying children who may be at risk for poorer school achievement. Elucidating the mechanisms underlying this association will require further research; however, in light of the increasing trend for performing elective early deliveries for nonmedical reasons, researchers, clinicians, and parents are urged to consider this graded relationship between weeks of gestation and school performance.

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