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Gestational age and socio-demographic factors associated with school performance at the age of 12 years, a population-based study

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Abstract

Background: Gestational age is positively associated with cognitive development, but socio-demographic factors also influence school performance. Previous studies suggested possible interaction, putting children with low socio-economic status (SES) at increased risk of the negative effects of prematurity.

Objectives: To investigate the association between gestational age in weeks, socio-demographic characteristics, and school performance at the age of 12 years among children in regular primary education.

Methods: Population-based cohort study among liveborn singletons ($N=860,332$) born in the Netherlands in 1999–2006 at 25–42 weeks' gestation, with school performance from 2011 to 2019. Regression analyses were conducted investigating the association of gestational age and sociodemographic factors with school performance and possible interaction.

Results: School performance increased with gestational age up to 40 weeks. This pattern was evident across socio-demographic strata. Children born at 25 weeks had −0.57 SD (95% confidence interval −0.79, −0.35) lower school performance z-scores and lower secondary school level compared to 40 weeks. Low maternal education, low maternal age, and non-European origin were strongly associated with lower school performance. Being born third or later and low socioeconomic status (SES) were also associated with lower school performance, but differences were smaller than among other factors. When born preterm, children from mothers with low education level, low or high age, low SES or children born third or later were at higher risk for lower school performance compared to children of mothers with intermediate education level, aged 25–29 years, with intermediate SES or first borns (evidence of interaction).

Conclusions: Higher gestational age is associated with better school performance at the age of 12 years along the entire spectrum of gestational age, beyond the cut-off of preterm birth and across socio-demographic differences. Children in socially or economically disadvantaged situations might be more vulnerable to the negative impact of preterm birth. Other important factors in school performance are maternal education, maternal age, ethnicity, birth order and SES. Results should be interpreted with caution due to differential loss to follow-up.

KEYWORDS
academic performance, education, gestational age, pregnancy complications, preterm birth, socio-economic status

1 | BACKGROUND

As the brain continues to grow and develop in utero until full gestation, increasing gestational age at birth has been associated with higher academic achievement.[1–5] Children born very preterm are more often lower educated and have lower-paying jobs.[3,4] In late preterm and early-term births, the association between gestational age and educational achievement persists, although the effect on the individual child is smaller.[5–7]

Besides gestational age, many biological and environmental factors influence school performance, and the relationships between these factors are complex.[1] Maternal education and socio-economic status (SES) are among the most well-studied factors.[8–10] Low maternal education level and low SES are associated with lower academic achievement of their children.[11,12] Other factors associated with offspring academic achievement include maternal age, ethnicity, birth order and sex.[1,13–16] Multiple of these risk factors are also associated with the risk of preterm birth. How these different factors influence the association between gestational age and offspring education outcomes needs further research.[17]

Most research on education outcomes of preterm birth is based on small cohorts of medical high-risk groups and are underpowered for analysis by week of gestation.[6,9,15,18] The influence of different environmental and biological factors on academic achievement is rarely analysed together, which makes it difficult to draw meaningful conclusions.[1,17,19] It is important for parents, clinicians, teachers, and society to understand how different factors are associated with gestational age and offspring education outcomes.

The aim of the study is to investigate, on a population level, the association between gestational age by week of gestation, socio-demographic characteristics, and school performance at the age of 12 years among children in regular primary education.

Synopsis

Study question?

What is the association between gestational age, socio-demographic characteristics and school performance at the age of 12 years?

What's already known?

Studies identified preterm birth, low parental education level, low socioeconomic status (SES) and low maternal age as risk factors for lower offspring education level.

What this study adds?

In this study, we describe that gestational age is associated with school performance, beyond the cut-off of preterm birth, across socio-demographic differences. Maternal education level, maternal age, ethnicity, birth order and SES are also associated with school performance, and children in socially or economically disadvantaged situations might be more susceptible to the consequences of preterm birth. This study corroborates previous findings and provides new evidence on the interaction between gestational age and several socio-demographic factors for offspring school performance.

2 | METHODS

2.1 | Study population

We conducted a population-based cohort study using linked data from the Netherlands Perinatal Registry (Perined) and Statistics Netherlands. The perinatal registry captures population-based information on 97% of all births in the Netherlands. Variables in the registry are recorded by caregivers. The perinatal registry was linked with the national Personal Records Database (deterministic linkage 97% successful) within the environment of Statistics Netherland to provide a unique number for each woman and child. This database was subsequently merged with the primary education registry. Statistics Netherlands stores all data collected by the Dutch government and many public bodies.

2.2 | Cohort selection

We selected all live born singleton births with gestational age at delivery from 25^{+0} weeks until 42^{+6} weeks born between 1999 and

2006 from the perinatal registry, with available standardised school performance score at the age of 12 years between 2011 and 2019 in the primary education registry. If a child in the education database was registered twice in two different years, the most recent year was used in the analysis. Children with congenital anomalies were excluded (Figure S1).

2.3 | Exposure

Data on gestational age at delivery, the onset of labour, maternal age at birth, birth order, ethnicity, SES, hypertensive disorders of pregnancy (HDP), diabetes mellitus (DM), infant sex, and birthweight were obtained from the perinatal registry. Gestational age was based on the crown-rump-length (CRL) measured during early pregnancy ultrasound. In the rare case this was not available, the last menstrual period was used. Preterm birth was defined as birth before 37 completed gestational weeks. Iatrogenic start of labour was defined as non-spontaneous start of labour (induction or elective caesarean). Birth order was divided into first born (parity 0), second born (parity 1) and third or later born (parity 2+). Maternal ethnicity was categorised in European (Dutch and other European, not Mediterranean), Mediterranean, African or South Asians, and 'other non-European' ethnicity. The Mediterranean group included mainly women from Morocco or Turkey. The African and South Asian groups were combined because of low prevalence in subgroups. Area-based SES score was calculated based on residences income, education level and unemployment level of a 4-digit zip code area. The value was categorised in quintiles, with the first quintile least affluent or low SES, and the fifth quintile most affluent. Birthweight centiles were calculated using the sex-specific Hoftiezer reference charts.[20] Small for gestational age (SGA) was defined a birthweight below the 10th centile for gestational age and sex.[21] Maternal education was obtained from the highest achieved education registry from Statistics Netherlands. It was divided into low (primary school and lower vocational education), intermediate (secondary vocational education or senior general education) and high (university or applied science).

2.4 | Outcomes

The outcome of interest was school performance measured on a standardised school performance test (Central Final Test) at the end of regular primary school (around the age of 12 years) and higher secondary school level.[22] The Dutch education system differs from that in many other countries by the fact that at the end of primary school children are divided into four different levels of secondary education according to their intellectual ability. It is compulsory for all children in the last year of regular primary education in the Netherlands to take a test officially recognised by the Dutch government in order to guide the level of secondary education. The Central Final Test is conducted by approximately two-thirds of all primary schools in the Netherlands; one-third of the schools use different tests.[23] Around 65% of the schools provide individual school performance scores to Statistics Netherlands. The Central Final Test covers compulsory subjects, including language and mathematics. The score ranges between 501 and 550, with a mean of 535 and standard deviation (SD) of 10. A score of 501–536 corresponds to a pre-vocational secondary school level, and a score of 537 or higher corresponds to a senior general or pre-university secondary school level (in this study referred to as 'higher secondary school level'). For this study, the school performance was transformed to a standardised school performance z-score with a mean of 0 and SD of 1 to enhance interpretability.

2.5 | Statistical analyses

Mean standardised school performance (i.e. z-scores) and corresponding 95% confidence intervals (CIs) were computed per week of gestation. Linear regression analysis was used to examine the association between gestational age and mean school performance z-score, using 40 weeks of gestation as the reference in all analyses. Proportion of higher secondary school level and the corresponding 95% CIs were calculated for each gestational age group (25–27, 28–31, 32–36, 37–39, 40 and 41–42 weeks), and binomial regression analysis with log-link function was conducted, using 40 weeks as reference. All analyses were adjusted for sex, birth order, maternal education level, maternal age, ethnicity and SES. Sensitivity analyses were conducted with additional adjustment for HDP, DM, SGA and iatrogenic start of labour.

Subsequently, mean school performance z-scores, proportions of higher secondary school level, and corresponding 95% CIs were calculated per week of gestation, stratified by different socio-demographic factors: sex, birth order, maternal education level, maternal age, ethnicity, and SES. Analyses were adjusted for age, and subsequently for all other sociodemographic and perinatal factors. Interaction on a multiplicative scale between gestational age and socio-demographic factors for higher secondary school levels was tested by adding an interaction term to the model containing the socio-demographic factor and gestational age. Proportions of higher secondary school level per gestational age group were calculated among groups of children with successively added socio-demographic risk factors for lower school performance, starting with the risk factor with the largest influence: low maternal education level, maternal age < 25 years, non-European ethnicity and low SES. Results are presented as (exponentiated) regression coefficients with 95% CIs. Data were analysed in the microdata environment of Statistics Netherlands using SPSS® (version 25.0), R (version 4.1.3) and Rstudio.

2.6 | Missing data

Missing values for covariates were < 1% for maternal age, birth order, ethnicity, birthweight and iatrogenic start of labour, 2.9% for

SES, and 49.4% for maternal education level (Table 1). We used the Multiple Imputation by Chained Equations (MICE) method in R with 50 iterations to impute missing values. There were no missing values for the covariates sex, HDP and DM.

2.7 | Ethics approval

Approval for data usage was obtained from Perined (approval number 19.43) and Statistics Netherlands (project number 8617, October 2019). No separate ethical approval is required under Dutch law.

3 | RESULTS

3.1 | Population

There were 1,337,559 liveborn singletons born between 25^{+0} and 42^{+6} weeks of gestation in the perinatal registry from 1999 to 2006 without neonatal mortality. For $N=872{,}059$ (65%) of these children, individual Central Final Test score was registered in the national primary education registry between 2011 and 2019 (linked population; Figure S1). After excluding children with congenital anomalies, $N=860{,}332$ remained for analysis.

For $N=465{,}500$ (35%) children in the selected perinatal registry cohort, Central Final Test score was not available in the national primary education database between 2011 and 2019 (Figure S1). This is largely because they attended schools that used a different school performance test or schools did not provide individual data (approximately 33%). These children were more often male, had slightly lower birthweights and had mothers that were slightly younger, less often European and more often with low SES (Table S1). There were $N=332{,}694$ children with education data between 2011 and 2019 that were not in the selected perinatal registry cohort, mainly because they were born before 1999, after 2006 or foreign-born (Figure S1). In these children, mean school performance was lower compared to the linked population (Table S1).

In the linked population, there were relatively more first borns and maternal age was lower among the children born preterm (Table 1, non-imputated data). The proportion of children born in a more favourable socio-economic situation, from European mothers and with high maternal education level increased with increasing gestational age. Characteristics of the linked population after imputation are shown in Table S2.

3.2 | Gestational age and school performance

Gestational age was continuously and positively associated with offspring school performance at the age of 12 years and higher secondary school level (Figure 1). Lowest school performance was seen in those born at 25 completed weeks of gestation, with the highest score in those born at 41 weeks. Adjusted for confounders, the mean school performance z-score at 25 weeks was −0.57 SD (95% CI −0.79, −0.35) lower compared to 40 weeks (Figure 2A, Table S3). Among all children, 50.3% reached a higher secondary school level. Following the lower school performance scores, adjusted risk for higher secondary school level among children born at 25–27, 28–31 and 32–36 weeks were lower compared to 40 weeks (Figure 2B, Table 2). Outcomes beyond the cut-off of preterm birth showed that children born at 37, 38 and 39 weeks had still had slightly lower school performance than at 40 weeks (Figure 2, Tables 2 and S3), adjusted for confounding factors. School performance z-scores and secondary school level of those born at 41 or 42 weeks were slightly higher in the unadjusted analyses; however, they did not differ from those at 40 weeks after adjustment for confounders. Sensitivity analyses adjusting additionally for HDP, DM, SGA and iatrogenic start of labour showed similar results (Figure S2, Table S4).

3.3 | Socio-demographic factors

Stratified by different socio-demographic factors, the association between gestational age and school performance z-score was similar across all subgroups, but with considerable differences in absolute school performance z-scores (Figure S3a–f). Children from mothers with low education level, below 25 years or from Mediterranean, African or South Asian origin had lower adjusted school performance z-scores and less higher secondary school level compared to children from mothers with intermediate education level, aged 25–29 years or from European origin. Third or later-born children or from mothers with low SES also showed lower school performance than first born children or children from mothers with intermediate SES, corrected for gestational age and other socio-demographic factors, but differences were smaller than among the other socio-demographic factors. Boys and girls showed similar results across all gestational ages. High maternal education level, maternal age at or above 30 years and high SES were associated with higher school performance z-scores at the age of 12 years (Figure S4, Tables S5 and S6).

Among all gestational ages, the proportion of higher secondary school level decreased when socio-demographic risk factors were successively added (Figure S5). Among children born at 40 weeks, 51.1% reached higher secondary school level; among children born at 25–31 weeks with all risk factors 16.7% reached higher secondary school level.

3.4 | Interaction between gestational age and socio-demographic factors

Children from mothers with low maternal education level had lower secondary school level when born early preterm (28–31 weeks) compared to children of mothers with intermediate education level

TABLE 1 Characteristics of the linked study population by gestational age.

	Gestational age at delivery (weeks)						
	25–27	28–31	32–36	37–39	40	41–42	Total
N	557	3348	40,643	368,041	242,107	205,636	860,332
Maternal age, mean (SD), years	30.2 (5.3)	30.2 (5)	30.2 (4.7)	30.6 (4.7)	30.5 (4.6)	30.5 (4.6)	30.5 (4.6)
Missing	0	0	0	2 (<0.1)	0	0	2 (<0.1)
Birth order							
First born	321 (57.6)	2242 (67.0)	25,857 (63.6)	166,235 (45.2)	107,792 (44.5)	102,430 (49.8)	404,877 (47.1)
Second born	148 (26.6)	725 (21.7)	10,029 (24.7)	135,827 (36.9)	92,307 (38.1)	69,929 (34.0)	308,965 (35.9)
Third or later born	87 (15.6)	377 (11.3)	4723 (11.6)	65,856 (17.9)	41,925 (17.3)	33,226 (16.2)	146,194 (17.0)
Missing	1 (0.2)	4 (0.1)	34 (0.1)	123 (<0.1)	83 (<0.1)	51 (<0.1)	296 (<0.1)
Socio-economic status							
1st quintiles (least affluent)	124 (22.3)	722 (21.6)	7798 (19.2)	67,435 (18.3)	42,170 (17.4)	35,685 (17.4)	153,934 (17.9)
2nd quintiles	110 (19.7)	639 (19.1)	7925 (19.5)	70,248 (19.1)	45,097 (18.6)	38,544 (18.7)	162,563 (18.9)
3rd quintiles	79 (14.2)	621 (18.5)	7714 (19.0)	70,106 (19.0)	46,635 (19.3)	39,345 (19.1)	164,500 (19.1)
4th quintiles	134 (24.1)	673 (20.1)	8626 (21.2)	78,818 (21.4)	51,921 (21.4)	43,985 (21.4)	184,157 (21.4)
5th quintiles (most affluent)	99 (17.8)	592 (17.7)	7554 (18.6)	71,466 (19.4)	49,084 (20.3)	41,819 (20.3)	170,614 (19.8%)
Missing	11 (1.9)	101 (2.9)	1026 (2.5)	9968 (2.6)	7200 (2.9)	6258 (3.0)	24,564 (2.9)
Maternal education level							
Low	99 (17.8)	428 (12.8)	4986 (12.3)	40,069 (10.9)	23,297 (9.6)	19,626 (9.5)	88,505 (10.3)
Intermediate	133 (23.9)	768 (22.9)	8701 (21.4)	73,018 (19.8)	45,926 (19.0)	38,396 (18.7)	166,942 (19.4)
High	99 (17.8)	646 (19.3)	7837 (19.3)	72,826 (19.8)	52,617 (21.7)	45,673 (22.2)	179,698 (20.9)
Missing	226 (40.6)	1506 (45.0)	19,119 (47.0)	182,128 (49.5)	120,267 (49.7)	101,941 (49.6)	425,187 (49.4)
Ethnicity							
European	437 (78.5)	2773 (82.8)	34,839 (85.7)	313,442 (85.2)	209,793 (86.7)	179,483 (87.3)	740,767 (86.1)
Mediterranean	50 (9.0)	238 (7.1)	2631 (6.5)	26,863 (7.3)	18,029 (7.4)	15,881 (7.7)	63,692 (7.4)
African/South Asian	44 (7.9)	186 (5.6)	1894 (4.7)	13,865 (3.8)	6643 (2.7)	5073 (2.5)	27,705 (3.2)
Other non-European	19 (3.4)	98 (2.9)	1017 (2.5)	11,245 (3.1)	5849 (2.4)	4036 (2.0)	22,264 (2.6)
Missing	7 (1.2)	53 (1.6)	262 (0.6)	2626 (0.7)	1793 (0.7)	1163 (0.6)	5904 (0.7)
Sex, male	277 (49.7)	1789 (53.4)	21,968 (54.1)	186,888 (50.8)	117,756 (48.6)	101,443 (49.3)	430,121 (50.0)
Birthweight, mean (SD), g	1019 (512)	1413 (407)	2568 (526)	3352 (474)	3609 (449)	3747 (464)	3473 (554)
Missing	0	1 (<0.1)	5 (<0.1)	81 (<0.1)	67 (<0.1)	42 (<0.1)	196 (<0.1)
SGA	145 (26.0)	1302 (38.9)	7356 (18.1)	41,637 (11.3)	26,423 (10.9)	20,081 (9.8)	96,944 (11.3)
Diabetes mellitus	(<1.0)[a]	18 (0.5)	529 (1.3)	4661 (1.3)	1590 (0.7)	782 (0.4)	(0.9)[a]
Hypertensive disorders of pregnancy	37 (6.6)	401 (12.0)	4324 (10.6)	25,814 (7.0)	11,115 (4.6)	8457 (4.1)	50,148 (5.8)
Iatrogenic start of labour	171 (30.7)	1510 (45.1)	8809 (21.7)	85,001 (23.1)	17,659 (7.3)	45,276 (22.0)	158,426 (18.4)
Missing	18 (3.2)	82 (2.4)	537 (1.3)	3007 (0.8)	1499 (0.6)	1740 (0.8)	6883 (0.8)

Note: Based on original non-imputed data. Unless otherwise indicated, data are presented as numbers (percentage).
Abbreviations: SD, standard deviation; SGA, small for gestational age.
[a]Insufficient data, not reported for privacy reasons.

(Table S7). Children from mothers below 25 or above 34 years had lower secondary school level when born late preterm (32–36 weeks) compared to children of mothers aged 25–29 years. Children born from mothers with low SES or born third or later had lower secondary school level when born early or late preterm (28–36 weeks) or early term (37–39 weeks) compared to children of mothers with intermediate SES or first borns. Children from women classified as 'other non-European' ethnicity had lower secondary school level when born extremely preterm (<28 weeks) compared to children of European women. Full results of the interaction analyses are described in Table S7. No interaction was noted between gestational age and sex.

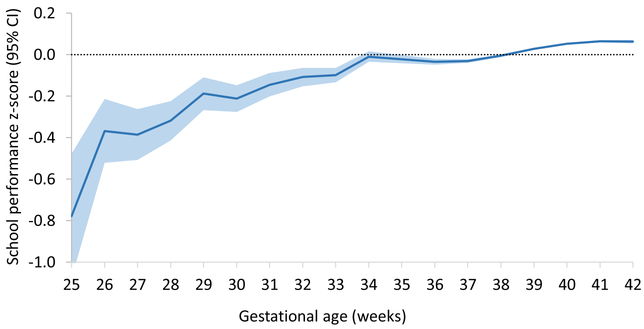

FIGURE 1 Mean school performance z-score and corresponding 95% confidence interval by week of gestation.

4 | COMMENT

4.1 | Principal findings

Gestational age is positively associated with school performance at the age of 12 years and secondary school level across socio-demographic differences, with school performance increasing up to 40 weeks. Low maternal education level, maternal age below 25 years, non-European ethnicity, high birth order and low SES are associated with lower school performance at the age of 12 years, with evidence of interaction with gestational age. Maternal education level and maternal age were the strongest socio-demographic factors associated with school performance, with differences in school performance similar to that found between children born very preterm and term infants.

4.2 | Strengths of the study

The major strengths of this study are the 97% complete population coverage of the birth records, the reliable identification of the mother and child, the extensive perinatal variable set, the large number of studied children and the sensitivity analysis.

4.3 | Limitation of the data

Inherent to the design of the study, our findings are limited to associations and do not necessarily imply causality. We did not have information on some potential confounders which could influence the association of gestational age and long-term education outcome, such as marital status, paternal education, maternal smoking or body mass index.[10,13,24] These unmeasured factors could give residual confounding.[5] Another limitation of the study is that part of the primary schools use a different test to assess school performance or do not provide individual school performances to Statistics Netherlands (approx. 35%). There is no information available on the characteristics of these schools. In our dataset, children without long-term education outcomes were more often born at lower gestational age, male sex and from women with lower maternal age, or non-European ethnicity, but differences overall are small. Moreover, children in special education because of cognitive, neurosensory or behavioural problems do not have to take the standardised school achievement test and are not accounted for in our analyses. The current results on offspring education outcome could therefore be an underestimation.[25]

4.4 | Interpretation

This study corroborates findings of previous studies that found that education grade averages of preterm borns are lower than those born at 40 weeks of gestation.[2–4,13,26] Some studies use preterm borns as one group and could not provide estimations separately for each week of gestation. In our study, the preterms born at 25 weeks scored after adjustment 0.57 SD (95% −0.79, −0.35) lower in school performance score. This was comparable to Garfield et al. who found that test scores for those born at 25–26 weeks were 0.43 SD (95% −0.39, −0.47) lower, and to Abel et al., who found that preterms born at 24 weeks were 0.43 SD lower in school performance.[5,13] Comparable to the results of Searle et al., every additional week of gestation within term borns was associated with higher school performance scores.[6] Van Beek et al.[26] describe a gradual improvement of academic attainment scores from 25 weeks up to 29 weeks. Our study builds on these results by showing that this gradual improvement continues up to 40 weeks. Contrary to Abel et al., in our study, there was insufficient evidence, after adjustment, to conclude that scores in those born at 41 and 42 weeks were different from scores in those born at 40 weeks.[5]

The associations we found between maternal education status, maternal age, ethnicity, birth order, SES and school performance are in line with other studies, although not frequently studied together.[9–12,14,16,17] The results of gestational age and school performance remained robust after adjustment for several socio-demographic factors as was shown by Yin et al.[27] This study adds to the literature a more detailed, per week of gestation analysis of the association of gestational age and school performance at the age of 12 years across the socio-demographic factors, providing evidence and visualising that the association between gestational age and offspring education outcomes persists despite absolute differences in school performance across socio-demographic differences. Additionally, our findings of interaction between gestational age and several socio-demographic factors corroborate the results of Mallinson et al, who showed that socio-economic advantage indicated by non-Medicaid coverage may diminish the costs of preterm birth on literacy skills.[28]

Continuous brain growth and maturation in utero without the damage associated with preterm birth is the likely underlying mechanism for the observed association between gestational age and school performance.[1,5] It underlines that prevention of preterm birth is crucial to optimise brain development and, in turn, school performance. At (near) term, the brain continues to grow with a 50% increase in cortical grey matter, providing an explanation for the

FIGURE 2 Crude and adjusted (A) difference in mean school performance z-score and (B) relative risk for higher secondary school level, with 95% confidence interval, at the age of 12 years by week of gestation age compared to 40 weeks. [a]Adjusted for maternal education, maternal age, birth order, ethnicity, SES and sex.

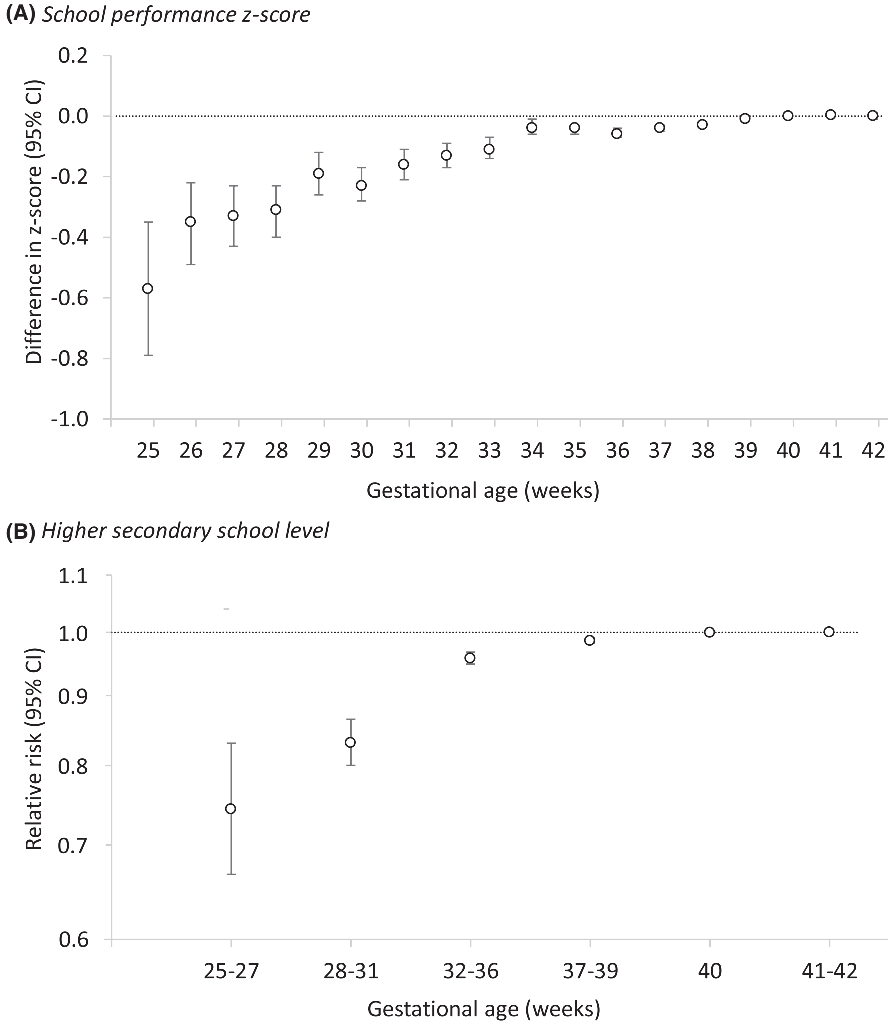

TABLE 2 School performance score and higher secondary school level at the age of 12 years by gestational age in weeks.

N = 860,332	School performance score	School performance z-score	Higher secondary school level			
Week	Mean (SD)	Mean (SD)	N/total	%	Unadjusted RR (95% CI)[a]	Adjusted RR (95% CI)[b]
Total	535.3 (9.9)	0.03 (0.99)	432,805/860,322	50.3	–	–
25–27	530.7 (11.1)	−0.43 (1.11)	189/557	33.9	0.66 (0.59, 0.75)	0.75 (0.67, 0.83)
28–31	533.0 (10.3)	−0.20 (1.03)	1351/3348	40.4	0.79 (0.76, 0.82)	0.83 (0.80, 0.87)
32–36	534.6 (10.1)	−0.04 (1.01)	19,313/40,643	47.5	0.93 (0.92, 0.94)	0.96 (0.95, 0.97)
37–39	535.1 (10.0)	0.01 (1.00)	181,779/368,041	49.4	0.97 (0.96, 0.97)	0.99 (0.98, 0.99)
40	535.5 (9.8)	0.05 (0.98)	123,815/242,107	51.1	1.00 (Reference)	1.00 (Reference)
41–42	535.6 (9.8)	0.06 (0.98)	106,358/205,636	51.7	1.01 (1.001, 1.02)	1.00 (0.996, 1.01)

Abbreviations: CI, confidence interval; RR, relative risk; SD, standard deviation.

[a]Binomial regression analysis with log-link function.

[b]Binomial regression analysis with log-link function, adjusted for maternal education, maternal age, birth order, ethnicity, SES and sex.

continuous association beyond the traditional cut-offs for preterm birth.[29,30] While the differences are relatively small near or at term for the individual child, it is because near or early terms constitute of a large proportion of all births that the impact on society could be substantial.[31]

This study demonstrates that, although preterm birth confers risks of developmental impairments, the effects of preterm birth on school performance are not uniformly deleterious, and other factors are also strongly associated with offspring education achievement.[13] For example, children born very preterm whose mothers have a high education level have school performances similar to those of children born full-term whose mothers have a low education level.

We find in our study that children in socially disadvantaged situations are more vulnerable to the negative impact of preterm birth. Put the other way around, children in socially and economically more affluent situations may have the ability to better overcome the negative effect of prematurity. Thus, while prevention of preterm birth is important, it can be reasoned that improving the maternal socioeconomic situation and education level is similarly relevant and could potentially improve offspring's long-term education outcomes.[12,32,33] Despite the improvement of childhood development is high on the international agenda, including through improvement of social and economic context, the implementation is fragmented and needs better coordination.[34] Improvement of the social and economic context might be specifically important, since these factors are also associated with the incidence of preterm birth. The additive influence of these factors on top of the negative influence of prematurity on school performance is also of importance when considering special risk groups for supportive interventions after birth or during school age, allowing optimisation of individual learning potential.

In this study, we explore the interplay between gestational age and different socio-demographic characteristics for school performance at the age of 12 years. In future studies, interactions between the different socio-demographic factors should be analysed in more detail, preferably in sibling analyses. If accessible, information on special education should be used and included as a separate outcome measure.[25] Moreover, paternal information including education level should be registered. Besides the mean school performance, analysis for specific language and mathematics score could be of use, when analysing specific subgroups of preterm birth. To follow up preterm born children and study final academic achievement after the age of 20 years and employment opportunities could provide additional knowledge.[35]

5 | CONCLUSIONS

Children born preterm or early term have lower school performances and lower secondary school level at the age of 12 years than those born at 40 weeks of gestation. Each additional week of gestation in utero is associated with higher school performance, across socio-demographic differences. Children in socially or economically disadvantaged situations are more vulnerable to the negative impact of preterm birth. Maternal education level, maternal age, ethnicity, birth order and SES are important factors in offspring school performance beside gestational age, with the potential to improve school performance at all gestational ages. Results should be interpreted with caution due to differential loss to follow-up.

AUTHOR CONTRIBUTIONS

RJB: project administration, methodology, writing – original draft and visualisation. SJG, BWM and WG: conceptualisation, methodology, writing – review & editing and supervision. TJR, EP, AAH, ME, AGL and CJMG: methodology, writing – review & editing and supervision. AR: conceptualisation, data curation, project administration, methodology, data verification, formal analyses, writing – review & editing and supervision. All authors approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

This research uses registry data from Statistics Netherlands and Perined. Results are based on calculations by the authors using microdata from Statistics Netherlands. These data are non-public linkable data at the level of individuals, companies and addresses that can be made available under strict conditions for statistical research. Statistics Netherlands has a policy on microdata sharing and analysis described online. Permission for analysis perinatal registry data (Perined) is described on their website.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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