



The role of parental education on the relationship between gestational age and school outcomes

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Abstract

Background: Individuals born preterm may experience difficulties beyond the neonatal period, such as poorer school outcomes. However, whether these outcomes are modified by family factors is less well-known.

Objectives: To investigate whether parental educational level modify the relationship of gestational age with completion of final examinations and grade point average in compulsory education.

Methods: This nationwide register-based cohort study included singletons born in Denmark during 1995-2001. We investigated the differences in the associations between gestational age (24-44 weeks) and two school outcomes at 16 years according to parental educational level (lower (≤ 10 years), intermediate (11-13 years), and higher (> 13 years)). Mixed-effect logistic regression and mixed-effect linear regression were used to model completion of final examination and grade point average, respectively.

Results: Of the 425 101 singletons, 4.7% were born before 37 weeks. The risk of not completing final examination increased with shorter gestational age and lower parental educational level. For instance, among adolescents whose parents had a lower educational level, the risk increased from 23.9% (95% CI, 23.1, 24.6) for those born in week 40 to 36.6% (95% CI, 31.5, 42.1) for those born in week 28. For adolescents whose parents had a higher educational level, the corresponding risk increase was 5.9% (95% CI, 5.7, 6.1) to 10.5% (95% CI, 8.6, 12.8), respectively. Grade point average decreased with shorter gestational age in adolescents born before 30 weeks and with lower parental educational level. The associations between gestational age and grade point average were similar across parental educational levels. For completions of final examination, the associations with gestational age were weaker with higher parental educational level.

Conclusions: Shorter gestational age and lower parental educational level were associated with poorer school outcomes. Our findings suggest that parental educational level mitigates the adverse effects of shorter gestational age on some school outcomes.

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**KEYWORDS**

adolescence, education, educational achievement, Gestational age, preterm birth, socioeconomic factor

1 | INTRODUCTION

Children born preterm (before 37 weeks) and early term (37–38 weeks) have higher rates of mortality and morbidity such as asthma and cerebral palsy.^{1–4} Apart from these more obvious sequelae, these children also have more subtle long-term difficulties such as cognitive delays^{4–6} and poorer school outcomes.^{4,7–12} These outcomes are important predictors of future education, occupation, and income.¹³

To gain a better understanding of how gestational age influences school outcomes and to identify factors that can improve these outcomes for children born after shorter gestation, it may be relevant to consider factors beyond the neonatal period such as social and family factors. Children from all socioeconomic backgrounds can experience adversities. Yet children from disadvantaged socioeconomic backgrounds are more likely to experience lack of cognitive stimulation and high levels of stress and may have fewer buffering resources.¹⁴ These experiences could influence learning ability negatively and through that school performance. Conversely, advantaged socioeconomic background may be related with more cognitive stimulation, parental academic expectations, and homework assistance which have been found to affect academic achievement positively.^{14–16} Advantaged socioeconomic background may either improve school outcomes for all gestational ages to the same extent or it may be particularly beneficial for high-risk groups such as preterm born children. Findings from studies investigating a potential effect modification by family factors on the association between preterm birth and school/cognitive outcomes have found support for both these hypotheses.^{17–26} Most of these previous studies considered preterm birth rather than the continuum of gestational age; however, also early-term birth has been associated with poorer school performance.^{4,8,9} In addition, maternal educational level has been associated with duration of pregnancy,²⁷ even within the term group.²⁸ It is therefore relevant to consider the full spectrum of gestational age. The aim of this study was to investigate the association between the full range of gestational age and school outcomes in adolescence and whether parental educational level modified these associations.

2 | METHODS

In this longitudinal register-based cohort study, we linked information from the Danish Medical Birth Register,²⁹ including gestational age, to register data on parental educational level and school performance in compulsory education. Individual-level data from the national registers were linked via unique personal identifiers³⁰ in an anonymised data set in Statistics Denmark.

Synopsis

Study question

Does parental education modify the relationship between gestational age and the school outcomes in adolescence: completion of final examination and grade point average?

What is known on this subject

Preterm birth and lower parental educational level are associated with poorer school outcomes.

What this study adds

Higher parental educational level mitigated the influence of shorter gestational age on some school outcomes in adolescence.

2.1 | Study population

A total of 471 088 individuals were recorded in the Danish Medical Birth Register²⁹ from 1995–2001, and this population was restricted to singletons ($n = 453\ 193$). Individuals who had died ($n = 2846$) or emigrated and had not returned to Denmark ($n = 12\ 023$) before 1 June the year they turned 16 years were excluded. Individuals with missing gestational age ($n = 9036$), with gestational age outside the range of 24 through 44 weeks ($n = 47$) and individuals with implausible relationships between gestational age and birthweight according to Alexander et al³¹ ($n = 701$) were excluded. In addition, individuals with missing exposure or covariate information were excluded ($n = 3439$, Table S1). The study population consisted of 425 101 singletons of which 366 563 had completed five mandatory examinations (Figure S1).

2.2 | Exposures

Information on gestational age in completed weeks was obtained from the Danish Medical Birth Register.²⁹ The estimates of gestational age were based on last menstrual period and/or ultrasound.³² Parental educational level in year of birth according to International Standard Classification of Education (ISCED) 2011³³ was obtained from the Population's Education Register.³⁴ The ISCED level of the parent with the highest attained or on-going educational level was used as a measure of parental educational level. If information on parental education was only available for one parent, then parental educational level was based on this parent's education. Parental educational level was categorised as: Lower (primary and lower secondary education, ISCED-level 1–2 [≤ 10 years]), intermediate (upper



secondary and short-cycle tertiary education, ISCED-level 3-5 [11-13 years]), and higher educational level (bachelor, master, doctoral education, or equivalent, ISCED-level 6-8 [>13 years]).

2.3 | Outcomes

Compulsory education in Denmark is equivalent to the ISCED-level lower secondary education. Nine years of education was compulsory during the study period starting from the age of seven³⁵; however, the majority of children started school at the age of six. Most pupils were 15-16 years when they took their final examination in compulsory education. The final examination consisted of two examinations in randomly selected subjects and five mandatory examinations in the following subjects: Danish literature, Danish writing (reading, spelling and writing), mathematics (with and without aids), English and physics/chemistry.³⁶ Individual-level subject-specific grades were obtained from the Academic Achievement Register in the school years 2008/2009 through 2017/2018.³⁴ Individuals who had sat and received grades in all five mandatory examinations were classified as having “completed final examination” irrespectively of whether they passed the examinations or not. Individuals who had not received grades in all five mandatory examinations were classified as having “non-completed final examination” (eg, adolescents with severe learning disabilities or pupils from Waldorf schools that have no grading tradition).

Grades were given on a 7-point scale with the following grades: -3, 0, 2, 4, 7, 10, and 12. The grade 12 designates an excellent performance and the grades -3 and 0 designate a non-passing level.³⁷ Grade point average (GPA) was based on grades designating passing and non-passing level from the five mandatory examinations in final grade of compulsory education.

2.4 | Covariates

Potential confounders were selected a priori based on knowledge from previous studies. Sex, birth year, and maternal age were available from the Danish Medical Birth register. Diagnoses of congenital anomalies according to the International Classification of Diseases 10th revision were obtained from the Danish National Patient Register.³⁸ These diagnoses were categorised as congenital anomalies excluding minor congenital anomalies according to EUROCAT guidelines.³⁹ Maternal country of origin was categorised as “Denmark,” “Western country,” and “Non-western country” according to Statistics Denmark's categorisation.⁴⁰ Potential confounders were categorised as seen in Table 1.

2.5 | Statistical analysis

Logistic mixed-effect model was used to investigate the outcome completion of final examination. Linear mixed-effect model was used

to examine the outcome GPA. The clustered nature of the data from mothers with more than one birth during the study period was taken into account in each model by including a random effect for mothers (identified by maternal id). In both models, the effect of gestational age was modelled as a continuous non-linear variable by using natural spline functions⁴¹ with three predefined knots (28, 37, and 41 weeks). Thus, the available data were used to determine the actual non-linear relationship between gestational age and school outcomes. To verify that the exact choice of knots did not by itself induce some effects, we compared a spline with six knots (28, 32, 34, 37, 39, and 41 weeks) to a spline with three knots (28, 37, and 41 weeks) in a subpopulation to examine whether three knots could capture the same association as six knots. The comparison showed similar association for the spline with six and three knots; therefore, we chose to use the spline with three knots. We included an interaction term between gestational age and parental educational level in each model to allow for interaction. The models were adjusted for the following potential confounders: sex, birth year, congenital anomalies, maternal age at birth, and maternal country of origin. For the outcome completion of final examinations, we estimated probabilities, which we refer to as risks (0%-100%) and these probabilities were used to calculate relative risks (RR). Further, additive interaction was explored by estimating the adjusted relative excess risk due to interaction (RERI).⁴² $RERI < 0$ indicates a negative additive interaction, $RERI > 0$ indicates a positive additive interaction, and $RERI = 0$ suggests no excess risk attributable to interaction. Confidence intervals for RR and RERI were calculated using a bootstrap technique with cluster sampling⁴³ (1000 iterations). For the outcome, GPA estimates are presented with 95% confidence intervals (CI).

2.6 | Missing data

The proportion of individuals with missing information on gestational age or one of the co-variables was 2.8%, and these individuals were excluded from the study population (Figure S1). Missing grade information was the outcome of interest as missing grades for a mandatory final examination designated that a pupil did not sit this examination and consequently did not complete final examination in compulsory education. For the outcome GPA, the analysis was restricted to individuals with grade information on five mandatory examinations (Table S1).

2.7 | Sensitivity analyses

To test the robustness of parental educational level as a measure of socioeconomic position, we fitted logistic and linear mixed-effect models with the following socioeconomic indicators: maternal education at birth, parental education at six years, and household income tertiles. Logistic and linear mixed-effect models including gestational age as a categorical variable (categorised as seen in Table 1) instead of as a spline function were also fitted. To investigate the

TABLE 1 Offspring and parent characteristics according to gestational age (study population n = 435 981)

	Gestational age categories						
	Extremely preterm (22-28)	Very preterm (28-31)	Moderate preterm (32-33)	Late preterm (34-36)	Early term (37-38)	Full term (39-41)	Post-term (42-45)
	510 (0.1)	2009 (0.5)	2491 (0.6)	14 804 (3.5)	65 673 (15.4)	302 211 (71.1)	37 436 (8.8)
No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)
Parental education							
Lower secondary	86 (17.1)	305 (15.2)	392 (15.7)	2166 (14.6)	8549 (13.0)	31 538 (10.4)	3773 (10.1)
Upper secondary	271 (54.0)	1110 (55.3)	1373 (55.1)	8230 (55.6)	35 663 (54.3)	159 378 (52.7)	19 633 (52.5)
Tertiary	145 (28.9)	594 (29.6)	726 (29.1)	4408 (29.8)	21 461 (32.7)	111 295 (36.8)	14 005 (37.4)
Maternal age							
≤24	84 (16.7)	372 (18.5)	478 (19.2)	2814 (19.0)	10 904 (16.6)	48 435 (16.0)	6157 (16.5)
25-29	153 (30.5)	697 (34.7)	859 (34.5)	5437 (36.7)	23 420 (35.7)	114 135 (37.8)	14 138 (37.8)
30-34	170 (33.9)	627 (31.2)	759 (30.5)	4396 (29.7)	21 396 (32.6)	100 785 (33.3)	12 415 (33.2)
≥35	95 (18.9)	313 (15.6)	395 (15.9)	2157 (14.6)	9953 (15.2)	38 856 (12.9)	4701 (12.6)
Maternal country of origin							
Denmark	439 (87.5)	1784 (88.8)	2276 (91.4)	13 182 (89.0)	57 535 (87.6)	272 419 (90.1)	34 289 (91.7)
Western	10 (2.0)	39 (1.9)	32 (1.3)	272 (1.8)	1205 (1.8)	5368 (1.8)	628 (1.7)
Non-western	53 (10.6)	186 (9.3)	183 (7.3)	1350 (9.1)	6933 (10.6)	24 424 (8.1)	2494 (6.7)
Birth year							
1995	54 (10.8)	284 (14.1)	335 (13.4)	2096 (14.2)	9145 (13.9)	46 246 (15.3)	5827 (15.6)
1996	81 (16.1)	295 (14.7)	358 (14.4)	2221 (15.0)	9248 (14.1)	44 085 (14.6)	5364 (14.3)
1997	61 (12.2)	268 (13.3)	260 (10.4)	1921 (13.0)	8464 (12.9)	41 181 (13.6)	5143 (13.7)
1998	58 (11.6)	302 (15.0)	373 (15.0)	2045 (13.8)	9063 (13.8)	42 717 (14.1)	5536 (14.8)
1999	84 (16.7)	292 (14.5)	377 (15.1)	2069 (14.0)	9353 (14.2)	42 920 (14.2)	5604 (15.0)
2000	77 (15.3)	294 (14.6)	377 (15.1)	2245 (15.2)	10 197 (15.5)	43 420 (14.4)	4912 (13.1)
2001	87 (17.3)	274 (13.6)	411 (16.5)	2207 (14.9)	10 203 (15.5)	41 642 (13.8)	5025 (13.4)
Sex							
Female	241 (48.0)	925 (46.0)	1108 (44.5)	6650 (44.9)	31 038 (47.3)	149 314 (49.4)	17 556 (46.9)
Male	261 (52.0)	1084 (54.0)	1383 (55.5)	8154 (55.1)	34 635 (52.7)	152 897 (50.6)	19 855 (53.1)
Congenital anomaly							
No	428 (85.3)	1779 (88.6)	2222 (89.2)	13 579 (91.7)	61 624 (93.8)	287 104 (95.0)	35 317 (94.4)
Yes	74 (14.7)	230 (11.4)	269 (10.8)	1225 (8.3)	4049 (6.2)	15 107 (5.0)	2094 (5.6)
Completion of final examination							
Completed	360 (71.7)	1531 (76.2)	1999 (80.2)	12 227 (82.6)	55 596 (84.7)	262 407 (86.8)	32 443 (86.7)
Non-completed	142 (28.3)	478 (23.8)	492 (19.8)	2577 (17.4)	10 077 (15.3)	39 804 (13.2)	4968 (13.3)

selection mechanisms from birth into adolescence, a multinomial logistic regression was modelled with an outcome with the following categories: death, emigration, completed final examination, and non-completed final examination.

All analyses were conducted in R version 3.5.0.

2.8 | Ethics approval

According to Danish legislation, no ethical permission is required for register-based research; however, this study was approved by the local data protection authorities.

3 | RESULTS

In this study population of 425 101 singletons, 4.7% were born preterm, 15.4% were born early term, 71.1% were born full term, and 8.8% were born post-term. The proportions of adolescents whose parents had lower, intermediate, and higher educational level were 11.0%, 53.1%, and 35.9%, respectively (Table S1). Among preterm and early-term born adolescents, the proportion of lower parental educational level was higher than among those born full term (Table 1). The proportions of males, adolescents with congenital anomalies and adolescents whose mothers were younger than 25 or older than 35 years at delivery were higher



in adolescents born preterm and early term than in those born full term.

A total of 366 563 (86.2%) had completed final examination, i.e., sat and received grade in five mandatory examinations in lower secondary education. Those who had not completed final examination had either completed one to four examinations ($n = 32\ 529$, 7.7%), no examinations ($n = 10\ 525$, 2.5%), or had not been registered in the Academic Achievement register ($n = 15\ 484$, 3.6%).

3.1 | Completion of final examination according to gestational age and parental education

The risk of not completing final examination increased with decreasing gestational age before 40 weeks and with lower parental educational level (Figure 1). For example, among adolescents whose parents had a lower educational level, the risk increased from 23.9% (95% CI, 23.1, 24.6) for those born in week 40 to 36.6% (95% CI, 31.5, 42.1) for those born in week 28. For adolescents whose parents had a higher educational level, the corresponding risk increase was 5.9% (95% CI, 5.7, 6.1) to 10.5% (95% CI, 8.6, 12.8), respectively. Compared with the reference group of adolescents born in week 40 with higher parental educational level, the RR was higher for adolescents born at 40 weeks with lower parental educational level (RR: 4.06, 95% CI, 3.94, 4.20) than for adolescents born in week 24 with higher parental educational level (RR: 2.87, 95% CI, 1.66, 4.44) (Table 2). The relationship between gestational age and non-completed final examination differed slightly across the different parental educational levels (Figure 1, Figure S2). To further investigate potential effect modification by parental education, we investigated additive interaction using RERIs. For those with either lower or intermediate parental educational level and shorter gestational age, the RERIs indicated a positive additive interaction (Table 2). For example, adolescents born in week 28 whose parents had a lower

educational level had a RR of 6.24 (95% CI, 5.37, 7.12) for not completing final examination compared with adolescents born in week 40 whose parents had higher educational level. The RERI for this group was 1.38 (95% CI, 0.42, 2.34) meaning that the combined effect was 1.38 more than the sum of the individual effects of 1) being born in week 28 and 2) having parents with a lower educational level.

Findings were similar when other measures of socioeconomic position (parental education at six years, maternal education, and household income) were used instead of parental education at birth (Figure S2 and Figure S3). When a categorical gestational age variable was included in the model for completion of final examination, the findings were similar to those from the main analyses (see Figure S4).

3.2 | Grade point average according to gestational age and parental education

Adolescents born between 30 and 44 weeks had similar GPAs (Figure 2). Before 30 weeks of gestation, shorter gestational age was associated with lower GPA. Overall, the associations between gestational age and GPA was slightly weaker in adolescents whose parents had intermediate educational level than among those whose parents had higher or lower educational level (Figure 2). Findings were similar when other measures of socioeconomic position (parental education at six years, maternal education, and household income) were used instead of parental education at birth (Figure S5). The GPA estimates from the model that included a categorical gestational age variable were similar to those from the main analysis (Figure S6).

3.3 | Sensitivity analysis

To address selection into the study population, we investigated how gestational age was related to death and emigration before 16 years.

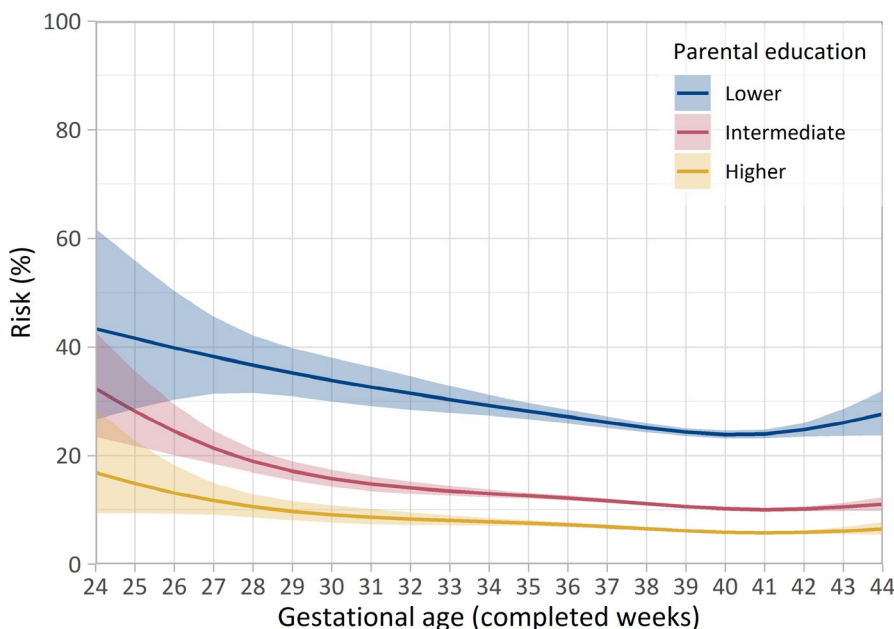


FIGURE 1 Risk of non-completed final examination according to gestational age and parental educational level. Areas represent 95% confidence intervals

TABLE 2 Relative risk (RR) and relative risk due to interaction (RERI) with 95% confidence intervals (CI 95%) for non-completed examinations according to gestational week and parental educational level

Gestational week	Parental education				
	Lower		Intermediate		Higher
	RR (95% CI)	RERI (95% CI)	RR (95% CI)	RERI (95% CI)	RR (95% CI)
24	7.38 (4.48, 10.37)	1.45 (-1.82, 4.73)	5.50 (4.04, 7.13)	1.90 (-0.27, 3.84)	2.87 (1.66, 4.44)
25	7.08 (4.82, 9.35)	1.49 (-1.00, 3.98)	4.79 (3.73, 5.96)	1.53 (0.02, 2.95)	2.53 (1.65, 3.52)
26	6.79 (5.12, 8.49)	1.49 (-0.28, 3.28)	4.16 (3.45, 4.93)	1.19 (0.24, 2.17)	2.23 (1.61, 2.90)
27	6.51 (5.31, 7.72)	1.46 (0.17, 2.69)	3.63 (3.17, 4.14)	0.91 (0.29, 1.57)	1.99 (1.54, 2.43)
28	6.24 (5.37, 7.12)	1.38 (0.42, 2.34)	3.22 (2.91, 3.56)	0.69 (0.24, 1.16)	1.80 (1.47, 2.14)
29	5.99 (5.25, 6.74)	1.28 (0.49, 2.10)	2.91 (2.65, 3.19)	0.52 (0.14, 0.93)	1.65 (1.38, 1.95)
30	5.77 (5.09, 6.42)	1.15 (0.46, 1.89)	2.68 (2.46, 2.94)	0.40 (0.07, 0.76)	1.55 (1.31, 1.81)
31	5.55 (4.96, 6.13)	1.02 (0.41, 1.68)	2.51 (2.32, 2.74)	0.31 (0.02, 0.62)	1.47 (1.26, 1.69)
32	5.35 (4.84, 5.86)	0.87 (0.37, 1.43)	2.39 (2.21, 2.58)	0.24 (-0.01, 0.51)	1.41 (1.23, 1.61)
33	5.16 (4.76, 5.57)	0.73 (0.33, 1.17)	2.29 (2.15, 2.45)	0.19 (0.00, 0.40)	1.37 (1.22, 1.52)
34	4.97 (4.68, 5.28)	0.59 (0.26, 0.94)	2.21 (2.11, 2.33)	0.16 (0.00, 0.31)	1.32 (1.21, 1.45)
35	4.80 (4.56, 5.05)	0.45 (0.17, 0.73)	2.14 (2.06, 2.24)	0.13 (0.01, 0.25)	1.28 (1.19, 1.38)
36	4.62 (4.41, 4.84)	0.32 (0.08, 0.55)	2.07 (2.00, 2.15)	0.10 (0.00, 0.21)	1.23 (1.16, 1.31)
37	4.44 (4.25, 4.63)	0.21 (0.00, 0.39)	1.99 (1.92, 2.06)	0.08 (-0.01, 0.16)	1.18 (1.12, 1.24)
38	4.27 (4.12, 4.43)	0.10 (-0.03, 0.23)	1.89 (1.83, 1.95)	0.05 (-0.01, 0.10)	1.11 (1.07, 1.15)
39	4.14 (4.00, 4.28)	0.03 (-0.03, 0.08)	1.80 (1.75, 1.85)	0.02 (0.00, 0.05)	1.05 (1.03, 1.06)
40	4.06 (3.94, 4.20)		1.73 (1.69, 1.78)		1.00 (reference)
41	4.08 (3.94, 4.23)	0.04 (-0.03, 0.10)	1.71 (1.66, 1.75)	-0.01 (-0.04, 0.02)	0.98 (0.96, 1.00)
42	4.21 (4.00, 4.43)	0.15 (-0.05, 0.36)	1.73 (1.66, 1.79)	0.00 (-0.09, 0.08)	1.00 (0.94, 1.05)
43	4.43 (4.03, 4.84)	0.33 (-0.10, 0.78)	1.79 (1.67, 1.91)	0.02 (-0.16, 0.20)	1.04 (0.93, 1.16)
44	4.71 (4.06, 5.39)	0.55 (-0.17, 1.29)	1.87 (1.67, 2.09)	0.04 (-0.26, 0.35)	1.10 (0.91, 1.30)

Note: RR and RERI were adjusted for sex, congenital anomaly, birth year, maternal age, maternal country of origin.

RERI was estimated for groups being "exposed" to gestational age above or below 40 weeks and those whose parents had either lower or intermediate educational level. The non-exposed group was those born at 40 weeks and whose parents had higher educational level.

RERI was estimated based on this formula $RERI = RR_{11} - RR_{10} - RR_{01} + 1$ (RR_{11} designate those being doubled exposed, RR_{10} designates those only exposed to gestational age and RR_{01} designate those only being exposed to parental educational level).

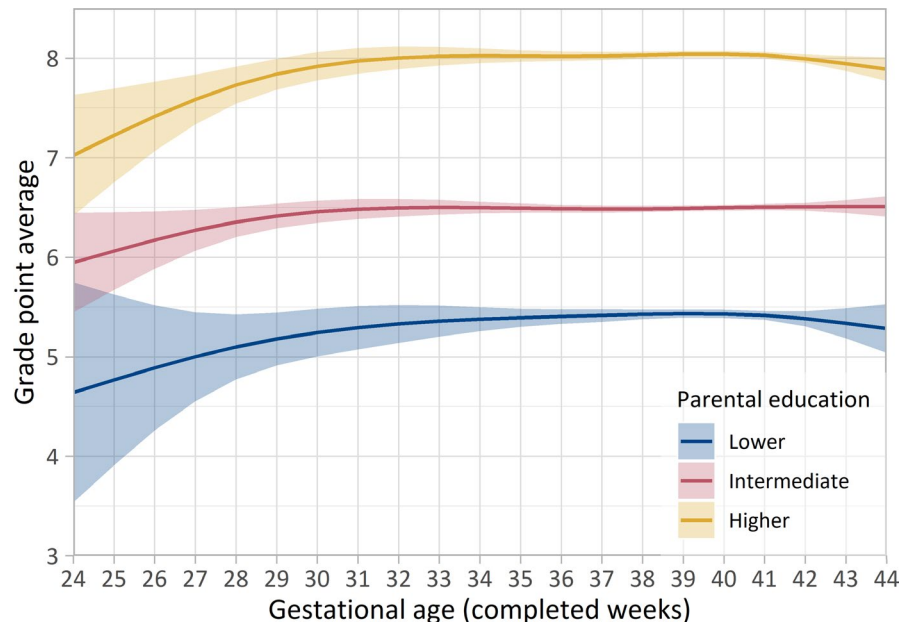


FIGURE 2 Grade point average according to gestational age and parental educational level. Areas represent 95% confidence intervals



Shorter gestational age was strongly related with mortality and less so with emigration (Figure S7).

4 | COMMENT

4.1 | Principal findings

In this study, both shorter gestational age and lower parental educational level were associated with non-completed final examination and lower GPA in final year of lower secondary education (15-17 years). While the risk of non-completed final examination decreased with higher gestational age, even within the term period, the disadvantage of shorter gestational age on GPA was confined to adolescents born before 30 weeks of gestation. Substantial parental educational differences in school outcomes were found at all gestational ages. Higher parental educational level mitigated the association between shorter gestational age and non-completed final examinations but not the association between shorter gestational age and GPA.

4.2 | Strengths of the study

The longitudinal nature of the national registers enabled us to follow all individuals born in Denmark from birth into adolescence. The large study population enabled us to investigate effect modification by parental education for the association between gestational age as a continuum and school outcomes. The perinatal and educational register information used in this study has a high validity^{29,34} and a relatively small proportion of missing data.

The majority of Danish adolescents take their final examination in lower secondary education in the year they turn 16 years. Yet, some individuals may postpone start of primary education and some may repeat a grade. Therefore, we included adolescents who took their final examination in the year they turned 17 to allow for one-year postponement.

Indicators of socioeconomic position measure different but often related aspects.⁴⁴ In this study, parental education was used as an indicator of socioeconomic position as it is relevant in early adulthood where most formal education is finished⁴⁴ whereas final income level may not have been reached yet. In line with that, maternal education has been observed to be more strongly related with preterm birth than for instance income and occupation.⁴⁵ However, other measures of socioeconomic position could be differently associated with gestational age and school outcomes. Therefore, we conducted the sensitivity analyses using other indications of parental socioeconomic position, such as maternal educational level and household income, and these revealed essentially the same results as the results from the main analysis.

4.3 | Limitations of the data

Overall, the level of missing information for gestational age was low; however, in 1997 the level of missing data on gestational age

increased to 9%, most likely because the Medical Birth Register underwent major changes in construction and content.²⁹ The different methods used to estimate gestational age gave rise to misclassification; however, this misclassification is most likely non-differential as it is unlikely that the methods to estimate gestational age are associated with school performance or registration of school performance. To reduce misclassification of gestational age, we excluded individuals with implausible gestational ages and implausible birthweight for gestational age. For grade information, a recent investigation found that inadequate registration contributed to a higher proportion of non-completed final examination, than what was actually the case.⁴⁶

We did not include birthweight as a potential confounder as the causality between birthweight and gestational age is ambiguous. In most cases, birthweight is a result of duration of gestation; however, in some cases, fetal growth restriction may lead to shorter gestation. In this study, birthweight was considered an effect of gestational age; however, we acknowledge that foetal growth restriction may be a confounder in some cases.

4.4 | Interpretation

More than a tenth of the adolescents had not completed all mandatory examinations in final grade of lower secondary education. This number corroborate data from the Ministry of Children and Education.⁴⁶ Importantly, those who did not complete final examinations had limited possibilities for entering further education as completion of all mandatory examinations was a requirement for entering the academic track of upper secondary education.⁴⁷ The group with non-completed final examination was diverse. Some adolescents were not recorded in the Academic Achievement register (eg, home schooled, Waldorf school's pupils), others were excused from the examinations (eg, adolescents with severe learning disabilities) or were absent (eg, due to sickness).

While the risk of non-completed examinations decreased for each additional week of gestation up to 40 weeks, lower GPA was limited to adolescents born before 30 weeks. A similar finding has been observed in another study.⁴⁸ Some adolescents such as those with learning difficulties are more likely to have poorer school performance⁴⁹ and presumably less likely to complete all mandatory examinations. In addition, adolescents with learning difficulties are also more likely to have lower gestational age.⁵⁰ Thus, the association between gestational age and GPA might have been more pronounced had it been possible for all adolescents including those with severe learning difficulties to sit the five mandatory final examinations.

The mechanisms linking shorter gestational age and school outcomes may among others include the underlying causes of shorter gestational age, early exposure to extrauterine environment, and increased morbidity related to shorter gestational age. Early exposure to the extrauterine environment may alter the brain development⁵¹ and thereby potentially affect cognition. In addition, individuals born preterm are more likely to experience morbidity,¹ which may impact the learning ability, that is, via school days lost

through illness or check-ups. Furthermore, preterm birth has been associated with bronchopulmonary dysplasia, cerebral palsy, and attention deficits which have also been associated with poorer school performance.^{7,52-56} Finally, the aetiologies of preterm birth are in most cases unknown,⁵⁷ and consequently, it cannot be ruled out that some of the underlying causes of preterm birth may affect school performance.

Adolescents who were exposed to both shorter gestational age and lower parental educational level had the poorest school outcomes as each factor contributed to poorer school outcomes. Higher parental educational level mitigated the association between gestational age and non-completed final examination but not between gestational age and GPA. This suggests that higher parental education is a universal protective factor that promotes school performance measured as GPA in adolescents born preterm and full term equally. For completion of final examination, higher parental education seemed to be a resilience factor that alleviated the disadvantage of shorter gestational age. Findings from previous studies on effect modification by family factors on the association between preterm birth and cognitive/educational outcomes have been inconsistent.^{17-25,58} Some studies found that the association between preterm birth and school/cognitive outcomes was weaker among those with advantaged compared with disadvantaged family factors.^{17,18,20,21,25} However, other studies found that the associations between preterm birth and school/cognitive outcomes were similar for those with advantaged and disadvantaged family factors.^{19,22-24} Different contexts such as different health care and educational systems could contribute to the mixed findings of previous studies as well as differences in length of follow-up period, methods used to investigate potential interaction or categorisation of gestational age, socioeconomic indicators, or outcomes. In this study, we investigated effect modification by four indicators of parental socioeconomic position and found similar results for these indicators. Additionally, categorisation of gestational age may impact findings as the mean gestational age within the preterm categories in general is shorter for individuals whose parents had a lower educational level compared with individuals whose parents had a higher educational level.^{45,59} Thus, the stronger association with adverse outcomes for preterm individuals from a disadvantaged socioeconomic background found in previous studies may reflect that these individuals have a shorter mean gestational age than preterm individuals from an advantaged socioeconomic background, that is, residual confounding. In this study, findings were similar when gestational age was examined in detailed categories and as a spline function.

This study shows substantial differences in school outcomes according to parental educational level and that higher parental educational mitigates the disadvantage of shorter gestational age on completion of final examinations. Thus, to improve school outcomes across all gestational ages but particularly for those born preterm it is crucial to investigate potential mediators in the association between parental socioeconomic position and school outcomes, such as homework assistance, parenting, and cognitive stimulation.

5 | CONCLUSIONS

Lower gestational age and lower parental educational level are associated with poorer school outcomes. Our findings suggest that higher parental educational level mitigates the disadvantage of lower gestational age on some school outcomes.

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DATA AVAILABILITY STATEMENT

Due to restrictions in Danish law, the confidential healthcare data used in this study can only be accessed through Statistics Denmark. Danish scientific organisations can be authorised to work with data within Statistics Denmark and can provide access to individual scientists inside and outside of Denmark.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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