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RESEARCH ARTICLE

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Low and very low birthweight disadvantage in compulsory education achievement and the transition to upper secondary education in the Finnish birth cohorts of 1987 to 1997

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Abstract

Background: We compared the educational achievements of very low-birthweight (VLBW) and low-birthweight (LBW) adolescents (ages 16 to 19) to those of their normal-birthweight (NBW) peers in the complete Finnish birth cohorts of 1987 to 1997. We focused on three key phases of the education process: the end of compulsory education (9th-grade completion), and the transition to and the completion of upper secondary-level education.

Methods: We used register data on grades, educational transitions and completed education. We employed multiple indicators on the progression of the education process and estimated population-level and within-families linear probability (LPM) models with robustness checks at the population level using logistic regression. We tested whether parental education and the child's sex modify the association between (V)LBW and educational achievement.

Results: Results of both descriptive analysis and the population-level and within-family LPM models indicate that (V)LBW is associated with an increased risk of not being able to keep up with the normative education process and to compete for upper secondary education study places at the end of compulsory education. The modifying effect of parental education was robust, whereas that of the child's sex was not. Among (V)LBW students who were able to keep up with the normative education process, (V)LBW was not associated with a lower grade point average or with a meaningfully lower probability of completing upper secondary education by the normative age.

Conclusions: The upper secondary-level educational choices and achievements of the children born with (V)LBW who managed to complete the standard compulsory education curriculum and complete the transition to upper secondary-level education within the expected time did not, in essence, differ from those of the NBW children. Some specific characteristics of the Finnish education system likely contributed to these results, such as the grading at compulsory education being only relatively loosely standardized.

KEYWORDS
child development, cognitive ability, developmental delay, gender, low birthweight, multidisciplinary

1 | INTRODUCTION

In this article, we compare compulsory and upper secondary education success between low-birthweight (LBW) (1500–2499 g) and very low-birthweight (VLBW) (<1500 g) groups and a reference group of normal-birthweight (NBW; ≥2500 g) individuals. We use individual-level administrative register data from complete Finnish birth cohorts from 1987 to 1997. In general, LBW disadvantage in cognitive skills and educational and other socioeconomic achievements in youth and adults is well established (e.g., Bilgin et al., 2018; Black et al., 2007; Lambiris et al., 2021; Silventoinen et al., 2023). The present study aims to add to the current knowledge on the association between (V)LBW and educational achievement in two ways.

Firstly, we conduct a comprehensive analysis of the education process by examining multiple outcomes. Many of the outcomes used in this study are rarely analysed concurrently or are overlooked in existing research. Our descriptive analysis includes multiple indicators of the progression of the education process and educational choices made at the end of compulsory education. Our regression models estimate the magnitude of the (V)LBW disadvantage in three key phases of the education process: (1) the end of compulsory education (9th-grade completion), (2) the transition to upper secondary-level education and (3) the completion of upper secondary-level education. As will be discussed in the following two sections, the first two of these phases are largely inseparable in the Finnish context. We focus on the ability to adhere to normative time frames in these phases and the 9th-grade grade point average (GPA). We analyse how the magnitude of the (V)LBW disadvantage in education varies when including and excluding individuals with a 'nonstandard' education process until the beginning of upper secondary-level studies. We also investigate whether parental education modifies the association between (V)LBW and educational achievement and whether the (V)LBW disadvantage differs between males and females.

Secondly, we delve into the evaluation and selection mechanisms that may contribute to observed differences or the lack thereof between birthweight groups. The Finnish education system, historically successful in the OECD's PISA studies assessing the basic skills of 15-year-olds, emphasizes equity among students (Ahonen, 2021). This prompts the question of whether the success of the Finnish education system extends to (V)LBW students. Does the (V)LBW disadvantage in educational achievement differ in Finland, or does it manifest in distinct ways compared to other developed Western countries? Although a direct answer to this question is beyond our scope, we aim to contextualize the magnitude of the (V)LBW disadvantage across different phases of the education process. In doing so, we not only highlight potential limitations in generalizability but also lay the groundwork for future studies seeking to contextualize (V)LBW disadvantage in diverse national education systems beyond Finland.

2 | BACKGROUND

The proportion of LBW (<2500 g) infants among all live births increased in most OECD countries from the 1990s until the 2010s (OECD, 2015). This upward trend was primarily attributed to a rise in maternal age, an increase in twin pregnancies (resulting from the growing utilization of fertility treatments) and a decrease in the mortality rates of LBW and preterm infants (Delnord et al., 2015; Euro-Peristat, 2013; OECD, 2015). These trends, including the increase in the proportion of preterm births, maternal age (among both primiparous and all mothers), the proportion of multiple births and the reduction in neonatal mortality, were observable in Finland during the same period (THL, 2022).

In alignment with these trends, in Finland between 1987 and 2017, the proportion of LBW infants among total life births rose from 3.3% to 4.1% among all mothers and from 4.1% to 5.4% among primiparous mothers (own calculations based on the Finnish Medical Birth Register data). Despite advancements in neonatal care, significantly improving the outlook for LBW and preterm infants compared with previous decades, infants born with LBW and preterm face an increased risk of cognitive and behavioural developmental problems (Goisis et al., 2017). The severity of these problems tends to be greater the lower the birthweight or the shorter the gestational age (Aarnoudse-Moens et al., 2009; Lundequist et al., 2015; Shenkin et al., 2004; Taylor et al., 2015).

A growing body of cross-disciplinary research—mainly in child psychiatry, developmental neuropsychology and paediatrics—compares cognitive and educational skills and behavioural problems between LBW and preterm children and NBW and full-term controls. These types of studies typically focus on subgroups of children with LBW and preterm birth, such as extremely (<1000 g) and very (<1500 g) low-birthweight children or extremely (<28 gestational weeks) and very (28–32 gestational weeks) preterm children. Difficulties of LBW and preterm children in keeping up with their peers in compulsory education are widely reported in Finland (Nyman et al., 2019) and elsewhere (Litt et al., 2005, 2012). Many LBW and preterm children have special education needs, or they require more additional support than their NBW and full-term peers when in standard classroom education (Hornby & Woodward, 2009; Litt et al., 2005; Nyman et al., 2019).

A growing body of social scientific, psychological and economic research focuses on the reinforcing and compensatory effects of family socioeconomic status (SES) on the association between poor perinatal health and child and adult outcomes. Various previous studies have found high family SES to compensate for—or low family SES to reinforce—the negative effect of poor perinatal health on cognitive, educational and other socioeconomic outcomes (Currie & Hyson, 1999; Gisselmann et al., 2011; Hines et al., 2020; Lin et al., 2007; Lin & Liu, 2009).

A growing body of paediatric and child psychiatric studies shows a lack of sex disparities in the educational abilities of preterm children (Nyman et al., 2019; Pritchard et al., 2009). Accordingly, a recent study in Finland did not find significant differences between very preterm boys and girls in standardized tests of educational abilities at the age of 11, and both very preterm boys and girls showed more problems than full-term same-sex controls (Nyman et al., 2019). However, the same study reported that boys had more classroom-functioning problems than girls in both the very preterm and control groups (Nyman et al., 2019). Regarding educational outcomes in adults, a previous register-based study in Sweden, a similar country context to Finland, did not report sex differences in how prematurity affected the completion of a university degree (Lindström et al., 2007).

3 | METHOD

3.1 | National context and data

In Finland, 9-year compulsory education (i.e., comprehensive school) begins at the age of 7 and lasts until 16 (for a description of the Finnish comprehensive school system, see Ahonen, 2021). Like the Finnish education system in general, the comprehensive education sector comprises practically all public institutions. The comprehensive education curriculum is essentially the same for each student, except for students with special education needs. Comprehensive education students with learning difficulties can receive so-called 'special support', or since 2011 also 'intensified support', enabling them to participate in the general education syllabus to the greatest extent possible instead of being placed in special education groups (Statistics Finland, 2019).

The end of compulsory education with the completion of the 9th grade is arguably the most critical phase in the education process in Finland. Dropping out from education after the end of 9th grade, the risk of which is higher for males than females, is one of the most significant predictors of marginalization as an adult in Finland (EVA, 2012). The first separation of educational tracks, between general and vocational upper secondary education, takes place after the end of 9th grade. Essentially, all the upper secondary-level study places are allocated by the Centralized Application System for Upper Secondary Level Study Places (CASSSP). The allocation process is mainly based on the 9th-grade GPA, and it uses a deferred acceptance algorithm, with each CASSSP participant naming up to five study programs in the order of his or her preference. The Finnish education system aims to guarantee an upper secondary-level study place for each 9th-grade finisher, and various programs exist to assist those without a study place. Although dropping out from education after the 9th grade was a possibility for the target birth cohorts of the present study, it has become practically impossible since the change in law in 2021. The law of 2021 prolonged the liability to participate in education from age 16 to age 18 (or until the completion of upper secondary-level education if this is achieved before the age of 18). Access to general upper secondary education, which is preparatory education for tertiary-level studies, is generally more selective than access to vocational education. Both general and vocational upper secondary diplomas take approximately 3 years to complete.

Our analysis is based on Statistics Finland's register data, which has been linked with the Finnish Medical Birth Register (FMBR) maintained by the Finnish Institute for Health and Welfare. The target group comprises the complete Finnish birth cohorts of 1987 to 1997. The FMBR began its records in 1987, rendering us unable to ascertain the birthweight of children born before that year. For children born after 1997, we lack information on all the relevant outcome variables. The exclusion criteria include death before the age of 20, missing information on the region and the type of municipality of residence, and a missing register-identifier for the biological father (the FMBR includes a register-identifier for each mother with a Finnish social security number). Furthermore, children from multiple births with more than two babies are excluded (the number of triplet, quadruplet, etc., children excluded before applying other exclusion criteria was 930). Data on birthweight were obtained from the FMBR. Indicators of the target birth cohorts' educational achievement were mainly sourced from the CASSSP data from 2003 to 2013. Although Statistics Finland provided the CASSSP data, the original source was the Finnish National Agency for Education.

3.2 | Outcomes and outcome-specific target groups

We analyse educational success with three main outcomes. The first outcome, the 'standard CASSSP', is a dichotomous variable for whether a person participated in the CASSSP with the standard 9th-grade diploma (standard syllabus in all academic subjects) by the normative age of 16. This outcome essentially controls whether a person was in the standard educational pipeline until the beginning of upper secondary-level studies. The target group for this outcome includes all individuals in the target birth cohorts. The administrative register data used for the study identify, in each year, individuals who participated in the CASSSP. However, these data do not allow for distinguishing between individuals who did not participate in the CASSSP because of not having completed compulsory education from those who had completed compulsory education but opted not to participate.

The second outcome is the 9th-grade GPA in academic subjects (Finnish/Swedish, 1st foreign language, 2nd foreign language, mathematics, biology, geography, physics, chemistry, health education, religious education and history). Because information on the 9th-grade GPAs is derived from applications submitted to the CASSSP system, it is available only for CASSSP participants. The 9th-grade GPA ranges between 4.0 and 10.0, and we analyse it as a continuous variable that is approximately normally distributed. In Finland, teachers follow common national evaluation criteria when giving the 9th-grade grades. However, these criteria are not strictly defined, leaving room for 'supportive grading'. When the birth cohorts of 1987 to 1997 finished the 9th grade, rigorous criteria were given only concerning what a student should master to obtain a grade of 8 in different subjects. Since then, the Finnish National Agency for Education has started the process of more rigorously defining what a student should master to earn a certain grade in different subjects.

To mitigate the absence of rigorous evaluation criteria and the resulting difficulties with the comparability of GPAs between students with different syllabuses (standard vs. adjusted) and study durations, we limit the target group for this outcome to those 9th-grade finishers who had had the standard CASSSP. That is, the target group for this outcome comprises individuals with the standard 9th-grade diploma completed by the normative age of 16 and who also participated in the CASSSP at the end of the 9th grade.

The third outcome, 'upper secondary education by the age of 19', is a dichotomous variable for whether a person completed any type of upper secondary-level education by the normative graduation age of 19. As discussed above, not having a post-compulsory education is one of the most significant risk factors for low income and marginalization in Finland. This outcome is based on the register information on the highest completed education at the end of the year when a person turned 19. The target groups for this outcome are the whole target birth cohorts and the subpopulation of individuals in those birth cohorts who received the standard CASSSP. Comparing results between these two target groups offers insights into the degree to which the failure to receive the standard CASSSP explains the failure to complete upper secondary education by the age of 19. Analysis using the whole birth cohorts produces results that are comparable with those of previous studies using similar unselected target groups.

3.3 | Independent variables: Birthweight group, sex and parental education

As discussed above, we separate three birthweight groups: VLBW (<1500 g), LBW (≥1500 and <2500 g) and NBW (≥2500 g) (no restrictions were set to the gestational age). Other independent variables include sex and mother's and father's education. We treat the mother's and father's education as time-invariant by identifying the highest completed education between the childbirths in the target birth cohorts. We distinguish among five educational categories: (1) compulsory education only (ISCED2011 level 2); (2) vocational upper secondary-level education (ISCED2011 levels 3–4); (3) general upper secondary-level education (ISCED2011 level 3; preparatory education to tertiary level); (4) short-cycle tertiary degree (ISCED2011 level 5 vocational degrees) and (5) tertiary-level degree (ISCED2011 levels 5–8). We further form a two-category education variable by merging the two lowest (1 and 2) and the three highest (3 to 5) categories. Using this two-category—high vs. low—education variable, we form four strata of parental education: (i) mother and father have high-level education; (ii) mother has high and father has low-level education; (iii) mother has low- and father has high-level education and (iv) mother and father have low-level education.

3.4 | Analytic plan

We estimate linear probability models (LPM) for the dichotomous outcomes of the standard CASSSP and the completion of upper secondary education by the age of 19 and ordinary least squares (OLS) regression models for the continuous outcome of 9th-grade GPA. LPM coefficients report the percentage points change in the probability of achieving the standard CASSSP or upper secondary-level diploma by the age of 19 for those with (V)LBW. We estimate three models for each of the three outcomes. Model 1 includes the birthweight group, the stratum of parental education, sex and the covariates (these will be discussed in the next section). Model 2 adds to Model 1 the interaction between the birthweight group and the stratum of parental education. Similarly, Model 3 adds to Model 1 the interaction between the birthweight group and sex. We use Model 2 to assess whether parental education modifies the association between (V)LBW and the three outcomes. We similarly use Model 3 to assess whether sex modifies the association between (V)LBW and three outcomes. We test the improvement in the model fit between Model 2 and Model 1 and between Model 3 and Model 1 with the likelihood ratio (LR) test.

We use within-family analysis to assess the robustness of the population-level results to omitted family conditions and parental background factors. We estimate the within-family (also known as sibling fixed-effects) specifications of Models 1, 2 and 3 for each of the three outcomes. We use suffixes 'A' and 'B' after the model number to differentiate between the population-level (A) and the within-family (B) specification of the same model. Within-family models are widely used in studies of how birthweight is associated with educational and other socioeconomic outcomes (Kinge, 2017; Torche & Conley, 2016). Within-family models compare siblings within each family and thus produce regression estimates for only those variables, which vary between siblings.

We employ LPM models as our primary models, preferring them over logistic models primarily because of their ease of interpretation. Coefficients from both population-level and within-family LPM models can be interpreted as individual-level marginal effects. In contrast, population-level logistic models and within-family logistic models, that is, conditional logistic models, do not yield causally comparable results between them (Petersen & Lange, 2020). Additionally, interpreting the results of within-family conditional logistic models is generally challenging (Petersen & Lange, 2020). As a robustness analysis, we replicated the population-level analysis using logistic models. These findings are reported in the Supporting Information. We chose not to replicate the within-family analysis using conditional logistic models because of the reasons discussed above.

Our family identifier groups together children of the same biological mother and father. We estimate all of our within-family models using a data set (i.e., family data) that includes only families with at least one child with VLBW or LBW and one child with NBW. In our main analysis, we do not use information on the children born outside of the inclusion period, that is, before 1987 or after 1997, except for the birth year of children born before 1987 for the birth order variable (see Section 3.5). To fully control for the sibling structure for the whole duration of the follow-up as well as each sibling's birthweight, we replicated the basic within-family model (1B) using homogenized family data from which all the mothers with children born before 1987 or after 1997 were excluded. These results are reported in the Supporting Information.

Because we treat the mother's and father's education as time-invariant, the stratum of parental education does not vary between siblings and thus cannot be included in the within-family models. However, the interaction between the birthweight group and the stratum of parental education can vary between siblings. This enables us to test improvement in the model fit between the basic within-family model (Model 1B) and the within-family interaction model (Model 2B). By doing so, we can check whether the compensatory (/reinforcing) effects of high (/low) parental education on (V)LBW disadvantage are robust to omitted family conditions and parental background factors. We estimate the basic population-level and within-family models (Models 1A and 1B) separately in the four strata of parental education and males and females for those outcomes for which the model fit improves significantly in the interaction models. The target population for the within-family analysis conducted in male siblings included all the families with at least one male child with VLBW or LBW and one male child with NBW. Within-family analysis in female siblings was conducted analogously. We further replicated the sex-stratified within-family analysis using information from only those families with all the children (i.e., full siblings) in the family being either males or females born between 1987 and 1997. By homogenizing the family data this way, we were able to fully control the sibling structure and sex composition for the whole duration of the follow-up, as well as for each sibling's birthweight. These results are reported in the Supporting Information.

We use STATA software (version 16.0) for all statistical analyses. We use Stata's (StataCorp., 2019) cluster-robust standard error estimators in all of our models to correct for dependencies between individuals sharing the same biological mother and father. Unlike regular standard errors, cluster-robust standard errors allow for correlations between individuals within the same family cluster.

3.5 | Covariates

Covariates used in the population-level analysis include the following: the child's birth year and month, the mother's and father's age at the childbirth (≤25, 26–30, 31–35, 36–40 and 41 ≥ years), the region of residence when the child was 16 years old (18 regions of the standard Finnish national classification with Åland Island combined with Southwest Finland), the type of municipality of residence when the child was 16 years old (rural, semi-urban and urban), twin birth (dummy variable), birth order (continuous), first language as Swedish (separate dummy variables for mother and father), foreign origin (separate dummy variables for mother and father) and cohabitation of biological mother and father when the child was 1 year old and 15 years old (two dummy variables). If the child's information on the region of residence and the type of municipality at the age of 16 was missing, the mother's information was used instead (the latest non-missing information between when the child was 1 to 16 years old). Covariates used in the within-family analysis were the same as in the population-level analysis excluding the two variables that do not vary between siblings: parent's first language as Swedish and foreign origin.

4 | RESULTS

4.1 | Descriptive results

The population-level data and the family data are described in Table 1. Of the 424 008 families included in the population-level data, 9856 (2.3%) were also included in the family data, that is, they had at least one child with VLBW or LBW and one child with NBW. Parent's level of education and other characteristics were very similar between the population-level and the family data. In the population-level data, the mean gestational age was 39.9, 35.8 and 29.7 weeks in the NBW, LBW and VLBW groups, respectively.

Figure 1 illustrates how VLBW adolescents and, to a lesser extent, LBW adolescents lag behind their NBW peers in completing compulsory education and participating in the CASSSP. 65.9% of individuals born with VLBW participated in the CASSSP by the age of 16, compared with 90.1% of those born with NBW. Additionally, the lower the birthweight group, the higher the proportion of the age group who participated in the CASSSP with an adjusted comprehensive education syllabus (i.e., those who had the CASSSP but not the 'standard CASSSP'). Table 2 provides more detailed information on the progression of the education process until the age of 20 in the three birthweight groups. Descriptive indicators showed little variation between the family data (see Table S1) and the population-level data (see Table 2), and the same conclusions apply to both datasets.

Only 48.9% of the VLBW group completed any type of upper secondary education by the age of 19, compared with 60.4% and 67.4% of the LBW and NBW groups, respectively (see Table 2). The difference in the overall graduation rates between the VLBW and NBW groups at the age of 19 was 18.5%. The corresponding difference was 12.8% at the age of 20. Thus, although reduced when providing an additional year to finish upper secondary-level education, the VLBW disadvantage in the overall graduation rate remained large.

Among individuals with the standard CASSSP, the 9th-grade GPAs were the same in each of the three birthweight groups. Similarly, when limiting the comparisons to individuals with the standard CASSSP, the proportions of applicants to vocational and general upper secondary education, as well as graduation rates by the ages of 19 and 20 from these two types of education, did not show any

TABLE 1 Summary statistics of the estimation samples.

	Population-level data	Family data[a]
Total number of singleton and twin live births between 1987 and 1997	685 056	
Exclusion of cases:		
No register-identifier for biological father[b]	8317	
Death by the age of 20	1966	
No information on the region and/or type of municipality of residence	144	
N (estimation sample)	674 629 (424 008 families)	24 499 (9856 families)
Singletons	657 937	19 499
Twins	16 692	5000
Birthweight group		
NBW (<1500 g)	651 673 (96.6%)	13 769 (55.2%)
LBW (1500–2499 g)	19 752 (2.9%)	9523 (38.9%)
VLBW (≥2500 g)	3204 (0.5%)	1207 (4.9%)
Mean gestational age (weeks; std in parenthesis)		
NBW	39.9 (1.4)	39.1 (1.7)
LBW	35.8 (2.5)	36.0 (2.4)
VLBW	29.7 (2.9)	29.5 (2.9)
Mother's education		
Tertiary	12.8%	12.9%
Lower-tertiary	24.4%	23.4%
Upper secondary level: General	14.2%	13.9%
Upper secondary level: Vocational	30.3%	30.6%
Compulsory education only	18.2%	19.3%
Father's education		
Tertiary	15.9%	15.4%
Lower-tertiary	14.5%	14.7%
Upper secondary level: General	7.1%	6.7%
Upper secondary level: Vocational	39.6%	40.4%
Compulsory education only	22.7%	22.7%
Stratum of mother's and father's education[c]		
(1st) high-level & high-level	28.6%	27.8%
(2nd) high-level & low-level	22.9%	22.3%
(3rd) low-level & high-level	9.0%	9.0%
(4th) low-level & low-level	39.5%	40.9%
Mother's age at birth (overall mean; std in parenthesis)		
Primiparas	27.1 (4.8)	27.1 (4.6)
Multiparas	30.8 (4.9)	30.4 (4.9)
Mother and father cohabiting (overall proportion)		
1 year after childbirth	96.5%	97.8%
15 years after childbirth	68.6%	71.7%
Foreign origin		
Mother	1.8%	1.7%
Father	2.2%	2.4%

[a]Families with at least one child with VLBW or LBW and one with NBW.
[b]Of these, 480 cases were excluded because of missing information on the father's year of birth.
[c]High-level education = general upper secondary-level, lower tertiary-level and tertiary-level education; low-level education = compulsory education only and vocational upper secondary-level education.

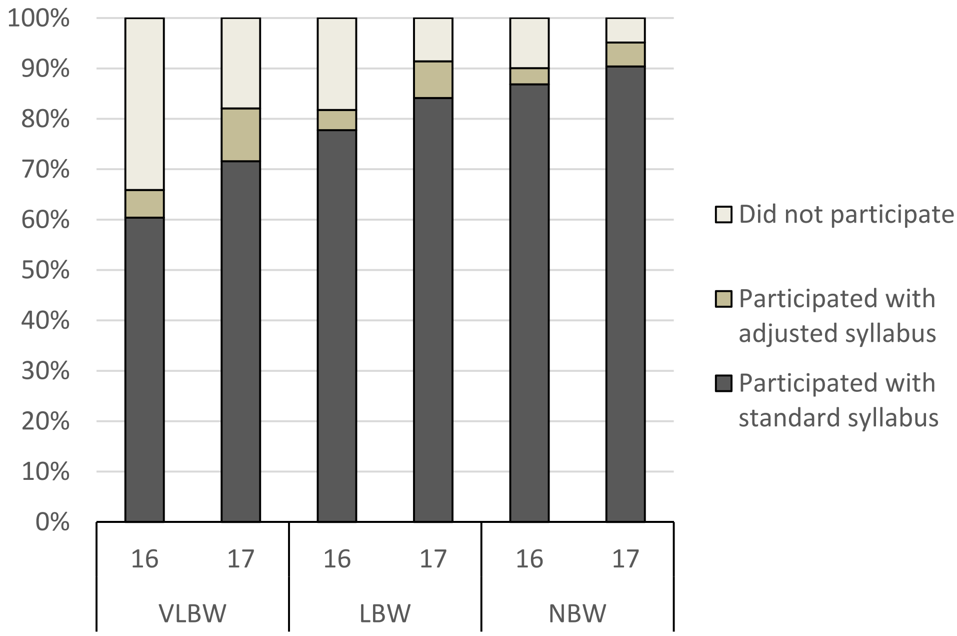

FIGURE 1 Cumulative participation rates in the Centralized Application System for Upper Secondary Level Study Places (CASSSP) by the ages of 16 and 17: differences among the birthweight groups in the population-level data (VLBW < 1500 g; LBW = 1500–2499 g; NBW ≥ 2500 g).

substantial differences among the birthweight groups (see the within-segment A rates and proportions in Table 2).

The importance of reaching the standard CASSSP for individuals born with VLBW is highlighted by the fact that the difference in the graduation rate from upper secondary education at the age of 20 between those with the standard CASSSP (see 'within-segment A rate' in Table 2) and everyone in the same birthweight category (see the respective 'overall rate' in Table 2) was the greatest among this birthweight group: 17.2 pp (85.0% vs. 67.8%). The respective difference was 9.5 and 5.2 pp among the LBW and NBW groups, respectively.

In all, the descriptive analysis suggests that neither VLBW nor LBW was associated with educational disadvantage among those having the standard CASSSP. That is, the post-compulsory educational choices and achievements of those children born with (V)LBW who managed to complete the standard curriculum within the expected time and complete the process that leads to a place in upper secondary-level education did not, in essence, differ from those of the NBW children.

Most of the 9th-grade finishers with an adjusted syllabus continued their upper secondary-level studies in vocational rather than general programs in each of the three birthweight groups (see Table 2). Surprisingly, however, among these students who had completed an adjusted comprehensive education syllabus, a greater proportion of those born with VLBW chose the academically more demanding general upper secondary school compared with those with NBW (9.0% vs. 2.2%; see the within-segment B proportions in Table 2). We leave it to future studies to determine whether this finding remains valid after controlling for the 9th-grade GPA and the specific differences in how the completed syllabus deviated from the standard one. Nevertheless, this result suggests that at least some students born with VLBW, who face difficulties in keeping up with their age group during compulsory education, may tend to choose the academically more demanding further education option after completing compulsory education.

4.2 | Differences among the birthweight groups

VLBW and LBW were associated with a significantly lower probability of participating in the standard CASSSP both at the population-level and within-family analyses (see Table 3). In the population-level analysis, the coefficients of VLBW and LBW were −0.254 and −0.083, respectively. In the within-family analysis, the VLBW's coefficient remained the same as in the population-level analysis, −0.254, whereas the LBW's coefficient was slightly less negative, −0.064.

Analysis of 9th-grade GPA was conducted among individuals who had the standard CASSSP. The respective within-family analysis was conducted using the information on only those children in the family having the standard CASSSP (see the notes of Table 3 for more details). No significant association between the birthweight group and 9th-grade GPA was observed in either the population-level or the within-family analysis (see Table 3).

Analysis of completing upper secondary education by the age of 19 was conducted both among the whole birth cohorts and among the subpopulation of individuals who had the standard CASSSP. When the target group comprised the whole birth cohorts, VLBW and LBW were associated with a significantly lower probability of completing upper secondary education by the age of 19 both in the population-level and in the within-family analyses (see Table 3). The coefficients of VLBW and LBW were −0.179 and −0.064 in the population-level analysis and −0.176 and −0.039 in the within-family analysis, respectively. When the target group comprised individuals

TABLE 2 Participation in the Centralized Application System for Upper Secondary Level Study Places (CASSSP), 9th-grade GPA, preferred choice of education in CASSSP and completion of upper secondary education: differences among the birthweight groups in the population-level data.

	VLBW (*n* = 3204)	LBW (*n* = 19 752)	NBW (*n* = 651 673)
CASSP by age 16:			
With standard syllabus ('standard CASSSP')	60.4%	77.7%	86.9%
With adjusted syllabus	5.5%	4.0%	3.2%
Total participation rate by the age of 16:	65.9%	81.8%	90.1%
CASSP for the first time at the age of 17:			
Standard syllabus	11.2%	6.4%	3.5%
Adjusted syllabus	5.0%	3.3%	1.6%
Total	16.2%	9.6%	5.1%
Total CASSSP participation rate by the age of 17:	82.1%	91.4%	95.1%
9th-grade GPA and education choices among individuals with the standard CASSSP (segment A)			
GPA: Mean (std)	7.8 (1.1)	7.8 (1.1)	7.8 (1.1)
Preferred choice of education in CASSSP (within-segment A proportions):			
General upper secondary school	58.3%	58.1%	57.5%
Vocational upper secondary school	40.7%	41.0%	41.7%
Education choices among comprehensive school finishers with adjusted syllabus (16- and 17-year-old first-time participants to CASSP) (segment B)			
The preferred choice of education in the CASSSP (within-segment B proportions):			
General upper secondary school	9.0%	3.6%	2.2%
Vocational upper secondary school	88.7%	93.7%	95.7%
Graduation rates from general upper secondary education (overall rate/within-segment A rate)			
By the age of 19	29.7/47.8%	38.7/49.1%	42.4/48.3%
By the age of 20	37.5/54.0%	45.0/55.1%	48.3/54.2%
Graduation rates from vocational upper secondary education (overall rate/within-segment A rate)			
By the age of 19	19.3/26.4%	21.7/24.9%	25.1/26.6%
By the age of 20	30.1/30.8%	30.4/29.9%	31.9/31.3%
Total graduation rates from any upper secondary-level education (overall rate/within-segment A rate)			
By the age of 19	48.9/74.2%	60.4/74.1%	67.4/74.9%
By the age of 20	67.8/85.0%	75.8/85.3%	80.6/85.8%

Note: Birthweight groups: VLBW < 1500 g; LBW = 1500–2499 g; NBW ≥ 2500 g. Number of cases used in calculating 9th-grade GPA: VLBW = 1935, LBW = 15 355 and NBW = 566 060. Note that 'segment A' and 'B' do not refer to any actual educational groups or categories in the Finnish education system but are used here simply to differentiate between indicators calculated among the students with and without the standard CASSSP, respectively.

who had the standard CASSSP, the association of LBW with completing upper secondary education by the age of 19 was significant, but only in the population-level analysis and with minimal effect size (−0.011). Among this restricted target group, the association of VLBW with this outcome was nonsignificant both in the population-level and within-family analyses.

4.3 | Differences by the stratum of parental education

The association between the stratum of parental education and each of the three outcomes was significant and gradient-like, or nearly so, in the population-level analysis (see Model 1A in Table 3). Model 2 added to Model 1 the interaction between the stratum of parental education and the birthweight group (see the LR tests for Model 2A vs. 1A, and 2B vs.1B, in Table 3). Improvement in the model fit in the interaction model was significant in participating in the standard CASSSP and in completing upper secondary education by the age of 19 (when the target group comprised of the whole birth cohorts) both in the population-level (Model 2A vs.1A) and within-family analysis (Model 2B vs.1B). For the 9th-grade GPA, improvement in the model fit was significant only in the within-family analysis (Model 2B vs.1B).

The population-level coefficient of LBW on the standard CASSSP increased (i.e., became more negative) systematically between the four strata, from −0.046 in the highest stratum to −0.109 in the lowest stratum (see Model 1A in Table 4). The respective population-level coefficient of VLBW was the least negative (i.e., had the smallest

TABLE 3 Population-level (Model 1A) and within-family (Model 1B) OLS and linear probability models (LPM) estimated separately for three outcomes: standard CASSSP (LPM), 9th-grade GPA (OLS) and completing upper secondary education by the age of 19 (LPM).

Outcome	Standard CASSSP		9th-grade GPA		Upper secondary education by age 19			
Target group	Whole birth cohorts		Individuals with the standard CASSSP		Whole birth cohorts		Individuals with the standard CASSSP	
Model	Model 1A	Model 1B[a]	Model 1A	Model 1B[b]	Model 1A	Model 1B[a]	Model 1A	Model 1B[b]
Birthweight group								
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.083***	−0.064***	0.004	0.024	−0.064***	−0.039***	−0.011**	−0.000
VLBW	−0.254***	−0.254***	0.006	0.020	−0.179***	−0.176***	−0.014	−0.026
The stratum of mother's and father's education								
(1st) high level–high level	Ref.		Ref.		Ref.	Ref.	Ref.	Ref.
(2nd) high level–low level	−0.026***		−0.477***		−0.051***		−0.038***	
(3rd) low level–high level	−0.036***		−0.472***		−0.067***		−0.049***	
(4th) low level–low level	−0.117***		−0.899***		−0.152***		−0.103***	
Sex: Male	−0.057***	−0.063***	−0.556***	−0.535***	−0.033***	−0.009	−0.003*	0.021**
N: Individuals/families	674 629/424 008	24 499/9856	583 350/382 290	17 003/7016	674 629/424 008	24 499/9856	583 350/382 290	17 003/7016
LR test of Model 2A vs. Model 1A	<0.001	-	0.790	-	0.001	-	0.958	-
LR test of Model 2B vs. Model 1B	-	<0.001	-	0.006	-	0.003	-	0.092
LR test of Model 3A vs. Model 1A	<0.001	-	0.040	-	0.225	-	0.045	-
LR test of Model 3B vs. Model 1B	-	<0.001	-	0.049	-	<0.001	-	0.332

Note: Coefficients and *p*-values are reported. Birthweight groups: VLBW < 1500 g; LBW = 1500–2499 g; NBW ≥ 2500 g. Model 2A (/B) = Model 1A(/B) + interaction between the birthweight group and the stratum of parental education. Model 3A (/B) = Model 1A(/B) + interaction between the birthweight group and sex.

[a]Families with at least one child with VLBW or LBW and one with NBW.

[b]Families with at least one child with VLBW or LBW and the standard CASSSP and one with NBW and the standard CASSSP.

*$p < .05$, **$p < .01$, and ***$p < .001$.

TABLE 4 Population-level (Model 1A) and within-family (Model 1B) OLS and linear probability models (LPM) estimated separately in the four strata of parental education for three outcomes: standard CASSSP (LPM), 9th-grade GPA (OLS) and completing upper secondary education by the age of 19 (LPM).

Outcome	Standard CASSSP		9th-grade GPA		Upper secondary education by the age of 19	
Target group	The whole birth cohorts		Individuals with the standard CASSSP		The whole birth cohorts	
Model	Model 1A	Model 1B[a]	Model 1A	Model 1B[b]	Model 1A	Model 1B[a]
1st stratum: Mother and father have high-level education						
Birthweight group						
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.046***	−0.046***	0.016	−0.022	−0.044***	−0.046***
VLBW	−0.217***	−0.193***	0.021	−0.053	−0.181***	−0.158***
N: Individuals/families	192 924/115 692	6810/2772	179 909/110 491	5695/2345	192 924/115 692	6810/2772
2nd stratum: Mother has high-level and father has low-level education						
Birthweight group						
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.065***	−0.073***	0.009	0.061*	−0.051***	−0.042**
VLBW	−0.244***	−0.287***	0.005	0.007	−0.177***	−0.256***
N: Individuals/families	154 468/95 552	5466/2225	138 850/89 252	4156/1716	154 468/95 552	5466/2225
3rd stratum: Mother has low-level and father has high-level education						
Birthweight group						
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.095***	−0.101***	0.007	0.047	−0.088***	−0.056**
VLBW	−0.274***	−0.254***	0.086	−0.083	−0.196***	−0.183**
N: Individuals/families	60 888/38 527	2200/870	53 574/35 295	1548/622	60 888/38 527	2200/870
4th stratum: Mother and father have low-level education						
Birthweight group						
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.109***	−0.062***	−0.013	0.023	−0.076***	−0.030*
VLBW	−0.273***	−0.262***	−0.023	0.142	−0.176***	−0.134***
N: Individuals/families	266 349/174 237	10 023/3989	211 017/147 252	5604/2333	266 349/174 237	10 023/3989

Note: Coefficients and *p*-values are reported. Birthweight groups: VLBW < 1500 g; LBW = 1500–2499 g; NBW ≥ 2500 g.
[a]Families with at least one child with VLBW or LBW and one with NBW.
[b]Families with at least one child with VLBW or LBW and the standard CASSSP and one with NBW and the standard CASSSP.
$^{*}p < .05$, $^{**}p < .01$, and $^{***}p < .001$.

effect size) in the highest stratum of parental education, but otherwise, it did not show any clear systematic differences among the strata. In the stratified within-family analysis of the same outcome, the VLBW and LBW coefficients were the least negative in the highest stratum of parental education, but no systematic differences could be observed among the other strata (see Model 1B for the standard CASSSP in Table 4).

The 9th-grade GPA did not, in essence, show meaningfully large discrepancies in the (V)LBW disadvantage between the different strata of parental education (see Models 1A and 1B in Table 4).

The coefficients of VLBW and LBW on completing upper secondary education by the age of 19 did not, in essence, show any clear differences among the four strata of parental education. This applied both in the population-level and within-family analyses (see Models 1A and 1B in Table 4).

4.4 | Sex differences

Males showed a significant disadvantage in each of the three outcomes in the population-level analysis (see Model 1A in Table 3). The male disadvantage remained significant in the within-family analysis of the standard CASSSP and 9th-grade GPA but not in the completion of upper secondary education by the age of 19 (see Model 1B in Table 3).

After adding the interaction between sex and birthweight group, for each of the three outcomes, the model fit improved significantly in the population-level model and/or within-family model in the LR test over the respective basic model (see the LR tests for Model 3A vs.1A, and 3B vs.1B, in Table 3). For the standard CASSSP and 9th-grade GPA, the model fit improved consistently both in the population-level and within-family analyses.

TABLE 5 Population-level (Model 1A) and within-family (Model 1B) OLS and linear probability models (LPM) estimated separately in males and females for three outcomes: standard CASSSP (LPM), 9th-grade GPA (OLS) and completing upper secondary education by the age of 19 (LPM).

Outcome	Standard CASSSP		9th-grade GPA		Upper secondary education by the age of 19	
Target group	The whole birth cohorts		Individuals with the standard CASSSP		The whole birth cohorts	
Model	Model 1A	Model 1B[a]	Model 1A	Model 1B[b]	Model 1A	Model 1B[a]
Males (/male siblings)						
Birthweight group						
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.093***	−0.069***	0.015	−0.015	−0.069***	−0.054***
VLBW	−0.279***	−0.295***	0.004	−0.032	−0.192***	−0.222***
N: Individuals/families	343 872/270 699	6639/2919	287 816/232 608	4233/1890	343 872/270 699	6639/2919
Females (/female siblings)						
Birthweight group						
NBW	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
LBW	−0.074***	−0.055***	−0.002	0.030	−0.060***	−0.025*
VLBW	−0.230***	−0.209***	0.009	0.136	−0.168***	−0.150***
N: Individuals/families	330 757/262 154	7039/3111	295 534/237 938	5234/2339	330 757/262 154	7039/3111

Note: Coefficients and *p*-values are reported. Birthweight groups: VLBW < 1500 g; LBW = 1500–2499 g; NBW ≥ 2500 g.
[a]Male(/female)-specific family data with at least one male(/female) child with VLBW or LBW and one NBW male(/female) child in each family.
[b]Male(/female) specific family data with at least one male(/female) child with VLBW or LBW and the standard CASSSP and one male(/female) child with NBW and the standard CASSSP in each family.
$^{*}p < .05$, $^{**}p < .01$, and $^{***}p < .001$.

In the sex-stratified basic models for the standard CASSSP (see Models 1A and 1B in Table 5), the VLBW disadvantage and, to a lesser extent, the LBW disadvantage were more pronounced among males than females both in the population-level and within-family analyses. For instance, the coefficient of VLBW on the standard CASSSP was −0.279 and −0.295 among males in the population-level and within-family analyses, respectively. Among females, the population-level and within-family VLBW-coefficients on this outcome were both less negative (i.e., had smaller effect sizes) than among males, at −0.230 and −0.209, respectively.

Despite the significant improvement in the model fit in the LR test both in the population-level and within-family analyses, no significant association between the birthweight group and the 9th-grade GPA was observed either among males or females in the sex-stratified basic models (see Models 1A and 1B in Table 5).

When the target group for completing upper secondary education by the age of 19 comprised the whole birth cohorts, the model fit improved significantly only in the within-family analysis (see LR test of Model 3B vs.1B in Table 3). In the sex-stratified basic models for this outcome, the coefficients of VLBW and LBW were more negative—particularly in the within-family analysis—among males than females (see Models 1A and 1B in Table 5). When the target group for this outcome comprised individuals who had had the standard CASSSP, the model fit improved significantly only in the population-level analysis (see LR test of Model 3A vs.1A in Table 3). However, the sex-stratified population-level models for this outcome, among this more restricted target group, did not in essence show meaningfully large differences between the birthweight groups among males nor females (see Table S2).

4.5 | Additional analysis

We replicated the population-level and within-family OLS models when using the 9th-grade mathematics and mother tongue (Finnish or Swedish) grade as the outcome instead of the 9th-grade GPA (both vary between 4 and 10). Similarly, when analysing the 9th-grade GPA, we analysed the 9th-grade mathematics and mother tongue grades among individuals with the standard CASSSP. Results for the 9th-grade mathematics grade are given in Table S3. Several previous studies in Finland and other national contexts have reported VLBW and very preterm birth to be associated with a greater deficiency in mathematics than in other types of skills or school subjects both in standardized tests and school exams (e.g., Aarnoudse-Moens et al., 2009; Aarnoudse-Moens et al., 2011; Alanko et al., 2017; Hagen et al., 2006). In the population-level analysis, the mathematics grade was significantly lower in the VLBW and LBW groups than in the NBW group, with coefficients of −0.191 and −0.053, respectively. In the within-family analysis, the LBW's coefficient did not remain significant. The VLBW's coefficient not only remained significant but also became greater (i.e., more negative) in the within-family analysis, −0.208. No significant differences were found in the 9th-grade mother tongue grade neither in the population-level nor in the within-family analysis (these results are not reported).

4.6 | Additional robustness checks

Table S4 provides results of the within-family analysis when the homogenized family data were used, that is, when excluding families with children born outside of the inclusion period (i.e., before 1987 or after 1997). Table S4 compares VLBW's and LBW's effect sizes and *p*-values between model types (population-level model vs. within-family model) and estimation samples (the full population, family and homogenized family data). VLBW's and, to a lesser extent, LBW's effect sizes remained generally similar between the three estimation samples and the model types in all three outcomes. Thus, the magnitude of the VLBW and LBW disadvantage appeared to be neither substantially nor systematically reduced after controlling for omitted family-level factors in the within-family analysis, or after further controlling for the family structure by homogenizing the family data.

Tables S5 and S6 provide results of the sex-stratified within-family analysis conducted among males and females, respectively, when we used the homogenized family data with all the children in a family being either males or females and born within the inclusion period. Both the original family data and the more homogenized version of these data produced in essence the same conclusion about the (V)LBW disadvantage being more pronounced among males than females compared with their same-sex siblings in these two outcomes.

We replicated the population-level analysis of the two dichotomous outcome variables (the standard CASSSP and completion of upper secondary education by the age of 19) using logistic regression. These results are given in Table S7 (see the AME-coefficients in that table). Conclusions regarding the main effects of the birthweight group, the stratum of parental education and sex remained essentially the same compared with those of the LPM models provided in Table 3 in the main text.

We also compared the results of the LR tests between LPM interaction models and respective logistic interaction models (see *p*-values of the LR tests for the population-level models in Tables 3 and S7). Adding the interaction between sex and the birthweight group for the standard CASSSP improved the model fit significantly in the LR test in LPM but not in the logistic model. This lack of consistency between the model types in the above respects was not surprising given that linear and logistic interaction models can produce different results even if the underlying main effects are the same (e.g., Ganzach et al., 2000). When considering that the overall failure rate in the standard CASSSP was only approximately 13.5%, the logistic model for this outcome can be, in principle, preferred over the respective LPM model due to that logistic models generally provide more reliable results when an outcome is a rare event (ibid.). Thus, the robustness of the result of (V)LBW disadvantage in the standard CASSSP being significantly more pronounced among males than females must be taken with some reservation. Likewise, for the outcome of completing upper secondary education by the age of 19 (when the target group comprised the whole birth cohorts), adding the interaction between the stratum of parental education and birthweight group improved model fit significantly in LPM but not in the logistic model. Despite the above-discussed differences in the LR tests between the different types of interaction models (LPM vs logistic), the respective basic LPM and logistic models estimated separately in the different strata of parental education and males and females did yield essentially the same conclusions (see the AME coefficients in Tables S8 and S9 and LPM coefficients in Tables 4 and 5).

5 | DISCUSSION

The aims of this study were twofold. First, we aimed to comprehensively analyse the magnitude of the (V)LBW disadvantage among the Finnish birth cohorts of 1987 to 1997 in the progression of the education process with multiple outcomes. The main outcomes included the normative completion of compulsory education (i.e., the 'standard CASSSP'), the 9th-grade GPA and the completion of upper secondary education by the normative age. We also tested if the (V)LBW disadvantage was moderated by the stratum of parental education and the child's sex. Our second aim—the aim for this section—was to connect the observed (V)LBW disadvantage in the different outcomes to relevant student selection mechanisms and policy aims of the Finnish education system.

The standard CASSSP included the following three criteria: (i) finishing the 9th grade by the normative age of 16; (ii) completing standard (as opposed to adjusted) compulsory education syllabus and (iii) applying for upper secondary-level study place in the CASSSP (Centralized Application System for Upper Secondary Level Study Places) without a delay after the completion of the 9th grade. The lower the birthweight group was, the lower the probability of participation in the standard CASSSP. This result is in broad accordance with various small-sample studies in Finland and elsewhere showing LBW (or preterm birth) to be associated with learning difficulties and behavioural problems in the school context (e.g., Hornby & Woodward, 2009; Litt et al., 2005; Nyman et al., 2019).

To mitigate the incomparability of grades among different types of students, we analysed 9th-grade GPA among students with the standard CASSSP (86.5% of the birth cohorts). Among this restricted target group, 9th-grade GPA was not significantly lower in the VLBW or LBW groups than in the NBW group. A previous study by Gisselmann et al. (2011) using Swedish register data found lower gestational age to be associated with lower 9th-grade Swedish-language grade in the lowest stratum but not in the other strata of parental education. We did not find any meaningfully large differences among the birthweight groups in 9th-grade GPA in any strata of parental education. However, differences in the research designs—including how poor perinatal health was operationalized (i.e., preterm birth vs. LBW)—make comparisons between our study and the aforementioned Gisselmann et al. (2011) difficult.

We suggest three explanations for the absence of any meaningfully large (V)LBW disadvantage in 9th-grade GPA in Finland. These explanations are not mutually exclusive. Rather, each of them is likely to contribute simultaneously.

First, the Finnish education system may simply function well in identifying and providing additional support for students with an innate disadvantage, such as (V)LBW. This interpretation is in line with the results of the PISA studies showing disparities in learning outcomes to be smaller in Finland than in most other developed countries (e.g., Ahonen, 2021).

Second, the learning requirements for different 9th-grade grades are not standardized in any strict sense in Finland, making 9th-grade GPA subject to biases. Systematic bias diluting differences among the birthweight groups could result from teachers tending to be more lenient in their evaluations towards students with an innate disadvantage, such as (V)LBW. That is, teachers may have lower expectations regarding the abilities of students with clearly observable (observable without having access to a student's medical records) developmental delays, leading them to grade these students less rigorously. However, estimating the extent to which this occurs is challenging and falls beyond the scope of this study.

Third, because of its composite nature, 9th-grade GPA is not very sensitive to deficiency in any specific subject (or skill). Our additional analysis showed that 9th-grade mathematics grades were significantly lower in the VLBW group and to a lesser extent also in the LBW group than in the NBW group. This finding remained for the VLBW children in the within-family analysis—indicating robustness to omitted family-level variables and parental background factors—but not for the LBW children. These results are in line with previous studies indicating that developmental problems associated with very low or extremely LBW (or with very preterm or extremely preterm birth) can affect mathematical skills more than other types of skills, such as language skills (e.g., Aarnoudse-Moens et al., 2009, 2011; Alanko et al., 2017; Hagen et al., 2006). These results also imply that even if the Finnish comprehensive education system succeeded well in supporting the (V)LBW students' passage through compulsory education, it does not mean that these students could not have difficulties in specific school subjects or skills such as mathematics.

The lower the birthweight group was, the lower the probability of completing upper secondary education by the normative age of 19 when assessed among the whole birth cohorts. This result is in accordance with previous studies in other Nordic countries reporting that poor perinatal health, operationalized either as LBW or preterm birth, is associated with a lower probability of having post-compulsory education (Black et al., 2007; Lindström et al., 2007). However, the (V)LBW disadvantage in this outcome almost disappeared in the population-level analysis and completely disappeared in the within-family analysis when individuals who had not had the standard CASSSP were excluded from the analysis. The absence of any meaningfully large (V)LBW disadvantage in completion of upper secondary education by the normative age and in 9th-grade GPA among individuals with the standard CASSSP suggests that any negative effect that (V)LBW may have on the highest educational attainment in adults in Finland results mainly from difficulties in achieving the standard CASSSP. In other words, (V)LBW did not appear to negatively affect the post-compulsory educational achievements among those able to participate in the competitive selection process for upper secondary-level study places with a standard 9th-grade diploma completed by the normative age.

Indicating robustness to omitted family-level variables and parental background factors, the conclusions regarding differences among the birthweight groups remained consistent between the population-level and within-family analyses in each of the three outcomes. As for the two dichotomous outcomes (the standard CASSSP and completion of upper secondary education by the age of 19), the conclusions about the differences between the birthweight groups remained essentially unchanged when logistic regression was used instead of LPM. However, the robustness of the results to the model type (LPM vs. logistic) could be assessed only in the population-level analysis.

The stratum of parental education significantly modified the association between (V)LBW and the standard CASSSP both in the population-level and within-family LPM models. In the population-level analysis, both when using LPM and logistic regression, the greater the (V)LBW disadvantage in the standard CASSSP, the lower the stratum of parental education. A more mixed picture emerged in the within-family analysis. Within-family LPM models suggested that although the (V)LBW's negative effect for the standard CASSSP is the lowest in the highest stratum of parental education, this effect is not disproportionally greater in the lowest stratum compared with the middle strata. In all, these results imply that highly educated parents may be able to better compensate for some of the negative effects of (V)LBW on their offspring's ability to complete the standard CASSSP. At the same time, they imply that the (V)LBW's negative effect on the standard CASSSP is not necessarily accentuated by low parental education.

Results of the sex-stratified analysis indicate that (V)LBW puts male children at a greater risk of not reaching the standard CASSSP than female ones. However, to some extent undermining the robustness of this result, sex was a significant modifier for this outcome only in the LPM model but not in the respective logistic population-level interaction model.

No meaningfully large discrepancies in the (V)LBW disadvantage in the completion of upper secondary education could be observed between the different strata of parental education or sexes when the target group was reduced from the whole birth cohorts to individuals with the standard CASSSP. This further emphasizes the importance of the above-discussed results that (V)LBW did not appear to negatively affect educational achievements among those being able to achieve the standard CASSSP.

6 | CONCLUSION

The present study highlighted that the extent to which and how (V)LBW disadvantage affects educational achievement cannot be understood in isolation from how a national education system evaluates and funnels students into different tracks. In Finland, (V)LBW disadvantage appears to be translated into educational disadvantage mainly through selectivity, that is, through completion of an adjusted compulsory education syllabus, through completion of the compulsory education one or more years older than the normative age or through drop-out after the end of 9th grade. Among the students who were able to keep up with the standard compulsory education syllabus and to transition to upper secondary level within the normative timeframe, (V)LBW was not associated with a lower 9th-grade GPA or with a meaningfully lower probability of completing upper secondary education by the normative age. The results that selectivity is a more important mechanism than lower grades in how (V)LBW disadvantage is translated into educational disadvantage reflects the traditional emphasis of the Finnish comprehensive education system on teaching basic skills to each student and trying to ensure a smooth transition to the upper secondary level for everyone. The Finnish education system has traditionally left rigorous student evaluations to post-compulsory education, particularly to general upper secondary education.

The present study provides robust support for the (V)LBW disadvantage being less pronounced among the highest strata of parental education in the standard CASSSP compared with lower strata. The result of the (V)LBW disadvantage in the standard CASSSP being more pronounced among males than females should be viewed with some reservation, as it was not robust to the model type. Future studies in Finland and elsewhere using similar outcomes should further investigate sex disparities in (V)LBW disadvantage.

The recent changes in the Finnish education system, including the move towards more standardized grading at the 9th grade and the extension of the mandatory education age to 18, mean that the outcome variables used for the present study do not have the same meaning for the age groups now completing their compulsory education. In addition to changes in the Finnish education system, demographic shifts such as lower birth rates and increased immigration may have altered, to some extent, the association between birthweight and educational outcomes compared with what was observed among the birth cohorts of 1987 to 1997. In addition, the proportion of 9th-grade finishers with poor learning outcomes has increased substantially among the more recent birth cohorts in Finland, as reported, for instance, by the PISA study of 2022 (OECD, 2023). This trend of the growing disparity between 'good' and 'weak' learners could be reflected in the (V)LBW disadvantage having become greater.

Despite the negligible differences in 9th-grade GPA, VLBW and, to a lesser extent (and only in the population-level analysis), LBW, children had significantly lower mathematics grades than their NBW peers. This finding suggests that VLBW, and to a lesser extent possibly also LBW, could be associated with choosing mathematically less demanding courses at the upper secondary level and beyond. It further implies that measures of overall educational achievement, such as the GPA at the end of compulsory education or the highest level of education achieved as an adult, may not capture all the relevant aspects of (V)LBW disadvantage in education. Future studies in Finland and elsewhere should explore this issue in greater detail.

AUTHOR CONTRIBUTIONS

Matti Lindberg: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; validation; visualization; writing—original draft; writing—review and editing.

CONFLICT OF INTEREST STATEMENT

The author reports no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Statistics Finland and Finnish National Institute for Health and Welfare. Restrictions apply to the availability of these data, which were used under license for this study. Researchers interested in using the data can apply access from Statistics Finland and Finnish National Institute for Health and Welfare.

ETHICS STATEMENT

The research conducted for this article used Finnish Medical Birth Register provided by Finnish Institute for Health and Welfare (research license no. THL/503/5.05.00/2018) and register data provided by Statistics Finland (research license no. TK-53-624-19). All of the data were pseudonymized according to European Union's General Data Protection Regulation (GDPR) act.

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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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