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ABSTRACT

Spillover Effects of Early-Life Medical Interventions*

We investigate the spillover effects of early-life medical treatments on the siblings of treated children. We use a regression discontinuity design that exploits changes in medical treatments across the very low birth weight (VLBW) cutoff. Using administrative data from Denmark, we first confirm the findings in the previous literature that children who are slightly below the VLBW cutoff have better short- and long-term health, and higher math test scores in 9^{th} grade. We next investigate spillover effects on siblings and find no evidence of an impact on their health outcomes. However, we find substantial positive spillovers on all our measures of academic achievement. Our estimates suggest that siblings of focal children who were slightly below the VLBW cutoff have higher 9^{th} grade language and math test scores, as well as higher probability of enrolling in a high school by age 19. Our results suggest that improved interactions within the family may be an important pathway behind the observed spillover effects.

JEL Classification: I11, I12, I18, I21, J13

Keywords: medical care, birth, children, schooling, spillovers

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1. Introduction

A growing body of research in economics shows that early-life medical interventions have significant effects on the outcomes of treated children. Medical treatments soon after birth have been found to substantially improve short-term health (e.g., Cutler and Meara, 1998; Almond et al., 2010; Daysal et al., 2015) and long-term outcomes such as academic achievement (e.g., Chay et al., 2009; Field et al., 2009; Bharadwaj et al., 2013). However, there is very little evidence on the impact of these treatments on other family members.[1]

In this paper, we add to the literature by investigating the spillover effects of early-life medical treatments on the siblings of treated children. Empirical identification of these effects is complicated by the fact that treatments are not randomly assigned. For example, shared genetic factors may impact both sibling outcomes and the receipt of medical treatments by targeted children. In order to address this endogeneity, we follow the previous literature and use a regression discontinuity design that exploits changes in medical treatments across the very low birth weight (VLBW) threshold (Almond et al., 2010; Bharadwaj et al., 2013). We focus on focal children with gestational ages above 32 weeks because children with gestational age below 32 weeks are covered by the medical guidelines for receiving additional medical treatments regardless of their birth weight.

Using register data from Denmark, we first investigate the effects of early-life medical treatments on focal children. Consistent with the previous literature, we find that children who weigh slightly less than 1,500 grams are more likely to

[1] One exception is Adhvaryu and Nyshadham (forthcoming), who exploit an iodine supplementation program in Tanzania and find that siblings of children who were exposed to treatment in utero were more likely to receive parental investments.

survive past the first year of life, to enjoy better health in the long run, and to have better math test scores in 9th grade. We next turn to spillovers on siblings. Our results indicate no differences in the health outcomes of siblings of children who were slightly below or slightly above 1,500 grams. However, we find substantial positive spillovers on all our measures of academic achievement. Our estimates suggest that siblings of focal children who were slightly below the VLBW cutoff have higher 9th grade language and math test scores, as well as higher probability of enrolling in a high school by age 19.[2] These results are robust to a host of specification checks. In addition, we find no evidence of discontinuities across the VLBW cutoff for outcomes of either focal children or their siblings when we restrict the sample to focal children with gestational age of less than 32 weeks.

There are several channels through which early-life medical treatments may affect the academic achievement of siblings. Siblings may be directly impacted if they are also exposed to the treatments (e.g., through increased doctor visits) or if the treatments improve parental health education. In addition, they may be affected indirectly due to changes in focal child outcomes. Indirect channels include potential changes in total household resources, intra-household allocation of resources, the general family environment (e.g., family structure and parental health), and the quality of parent-child and sibling interactions.

We show that direct exposure to treatments and changes in total resources and intra-household resource allocation are unlikely to be the main drivers of our results. Although data limitations do not allow us to investigate directly the role of parent-child and sibling interactions, we provide several results corroborating their importance. First, consistent with previous medical findings (Sinn et al.,

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[2] During our study period, Denmark had nine years of compulsory education. Loosely speaking, high school included grades 10-12.

2002), we show that focal children slightly below the VLBW cutoff are substantially less likely to have intellectual disability. Second, we find that the mothers of treated children have better mental health soon after the focal child is born. Finally, we find evidence of heterogeneity in the spillover effects on sibling academic achievement by sibship characteristics that are most closely tied to the quality of peer interactions (gender of sibling, gender composition of the sibling pair, and birth order).

Our paper makes several contributions. First, we add to the economic literature on returns to early-life medical interventions. This literature almost exclusively studies effects on treated children. We are aware of only one study on spillover effects with a causal interpretation, by Adhvaryu and Nyshadham (forthcoming).[3] This study is based on an intervention in a developing country and examines how parents allocate investments in the health of their children. In contrast, we focus on both sibling health and academic achievement outcomes in the context of a developed country.

Second, we contribute to the growing literature linking child health to sibling outcomes (e.g., Fletcher and Wolfe, 2008; Fletcher et al., 2012; Parman, 2013; Breining, 2014; Black et al. 2014). The majority of this literature focuses on the effects of having a disabled sibling and thus informs on spillover effects due to childhood endowments. We, on the other hand, look into the role of medical interventions in generating spillovers. This is an important distinction because knowing that health endowments lead to spillover effects does not necessarily imply that medical treatments can mitigate these effects. Moreover, the medical

[3] There is some evidence on sibling spillovers from policies or interventions more broadly. For example, Dahl et al. (2014) show that take-up of family friendly policies affects siblings' subsequent use of these policies, and Joensen and Nielsen (2014) consider sibling spillovers from exposure to high-level math.

interventions considered in this paper may have health benefits even among non-disabled individuals. As a result, we capture spillovers across a wider range of endowments.

2. Institutional Background

The majority of Danish health care services, including birth related procedures, are free of charge and all citizens have equal access (Health Care in Denmark, 2008). Similar to many other countries, Denmark follows the World Health Organization definition of prematurity where a child is defined as premature if (s)he is born before 37 weeks of pregnancy or with a birth weight below 2,500 grams. Within this group a distinction is made between children with very low birth weight, defined as less than 1,500 grams (or below 32 weeks of gestational age) and children with extremely low birth weight, defined as less than 1,000 grams (or below 28 weeks of gestational age).

The first European neonatal intensive care unit was established in 1965 at Rigshospitalet in Denmark and the use of early-life medical technologies has since followed the international development (Mathiasen et al., 2008). Danish neonatal medicine textbooks pay particular attention to children with a birth weight below 1,500 grams and emphasize these as being especially at risk of different complications. The VLBW classification is frequently found in medical research papers based on Danish data where the focus is often on their higher mortality rates (e.g., Thomsen et al., 1991; Hertz et al., 1994). Specific recommendations in terms of nutrition and vitamin supplements exist for this group (Peitersen and Arrøe, 1991). In addition, papers indicate that children below 1,500 grams are more likely to receive additional treatments such as cranial ultrasound (Greisen et al., 1986), antibiotics (Topp et al., 2001), prophylactic treatment with nasal continuous positive airway pressure (nCPAP), prophylactic surfactant treatment and high priority of breast feeding, and use of the kangaroo method (Jacobsen et al., 1993; Verder et al., 1994; Verder, 2007; Mathiasen et al., 2008).

Anecdotal evidence from hospital and regional specific notes outline special services that are provided to families with premature children below 1,500 grams (or below 32 weeks of gestational age). These services include referrals to a physiotherapist who guides and instructs the parents on how to stimulate the development of the child and on various baby exercises. It is also mentioned that all premature children below 1,500 grams (or below 32 weeks of gestational age) are routinely checked 1-2 months after discharge and again when they are five months, one year and two years old.

3. Conceptual Framework

Early-life medical interventions provided to VLBW children may impact the socio-economic outcomes of their siblings both directly and indirectly. As discussed in the previous section, VLBW children benefit from additional medical resources. These resources may directly improve the health of siblings if they are also exposed to the treatments (e.g., increased routine checks) or if the treatments help parents understand the role of different health inputs.

Siblings may also be impacted indirectly through changes in VLBW child outcomes. Medical interventions early in life improve the survival, short-term health and later-life academic achievement of treated children. Previous literature links child health to resources available within the family. For example, parents of children in worse health tend to work less (Powers, 2003; Corman et al., 2005; Noonen et al., 2005; Wasi et al., 2012; Kvist et al., 2013). While this may reduce total family income, it may also increase available time for parent-child interactions both for the sick child and for their siblings. In addition, child health may lead to changes in intra-household resource allocation. A large literature in economics documents that parental investments are a function of children's early life endowments (see Almond and Currie, 2011, and Almond and Mazumder, 2013, for a review of this literature). Empirical evidence on how parents change their resource allocation is mixed. Some studies find that parents tend to reinforce differences in early life endowments (e.g., Rosenzweig and Wolpin, 1988; Behrman et al., 1994; Parman, 2013) while others find evidence of compensating behavior (Behrman et al., 1982; Pitt et al., 1990; Bharadwaj et al., 2014; Adhvaryu and Nyshadham, forthcoming).

Previous literature also finds an association between child health and changes in family environment. For example, poor child health is linked to higher likelihood of family dissolution (e.g., Corman and Kaestner, 1992; Reichman et al., 2004; Kvist et al., 2013), which is in turn tied to worse child outcomes (e.g., Manski et al., 1992; Haveman and Wolfe, 1995; Ginther and Pollak, 2004). Similarly, child health is associated with parental well-being. Previous evidence shows a positive association between child mortality and the risk of psychiatric and physical health problems of parents (e.g., Levav et al. 2000; Li et al., 2003; Li et al., 2005), which are important inputs in child development.

Finally, sibling outcomes may be impacted through changes in the quality of peer interactions. Previous psychological studies suggest that older children may act as "role models" for younger siblings (e.g., Dunn, 2007). This is consistent with the economic research linking younger siblings' educational outcomes and risky behavior to their older siblings (e.g., Oettinger, 2000; Ouyang, 2004; Altonji et al., 2010) and suggests that health and academic achievement gains resulting from early-life medical interventions may have positive spillovers to outcomes of younger siblings.

Overall, this discussion indicates that the direction of the spillover effects of early-life medical interventions is theoretically ambiguous and ultimately an empirical question.

4. Empirical Strategy

The goal of this paper is to estimate the effect of early-life health interventions on the siblings of targeted children. Identification of these effects is complicated by the non-random assignment of medical treatments. In particular, there may be unobserved determinants of sibling outcomes that are correlated with the receipt of medical treatments by targeted children, such as shared genetic factors. In order to address this endogeneity, we follow Almond et al. (2010) and Bharadwaj et al. (2013) and use a regression discontinuity design that exploits changes in medical treatments across the VLBW threshold. We start by replicating the findings in the previous literature investigating the impact of medical technologies on treated children using the following equation:

$$y_{jt} = f\left(bw_j - 1500\right) + \alpha VLBW_j + u_{jt} \tag{1}$$

where y_{jt} is an outcome of child j at time t, bw_j is the birth weight of child j, $f(\cdot)$ is a first-degree polynomial in our running variable (distance to the VLBW cutoff) that is allowed to differ on both sides of the cutoff, and $VLBW_j$ is an indicator for child j being very low birth weight (i.e., $bw_j < 1500$).

We then move on to estimating the effects of these medical interventions on siblings through the following equation:

$$y_{ijt} = f\left(bw_j - 1500\right) + \beta VLBW_j + \epsilon_{ijt} \tag{2}$$

where subscript i indicates sibling i of treated child j. The parameter of interest, β, is an intention-to-treat estimate of the (life-course) effects that additional medical treatments received by VLBW newborns may have on their siblings.

Our baseline regressions use a triangular kernel that assigns decreasing weights to observations farther away from the cutoff. We choose our bandwidth based on a cross-validation procedure similar to Almond et al. (2010). In particular, we estimate the relationship between our outcome variables and birth weight using a local linear regression and a fourth-order polynomial model. The models are estimated separately above and below the VLBW threshold. We then calculate the bandwidth that minimizes the mean squared error between the predictions of these models. For mortality outcomes, the bandwidth is 190 grams; for long-term health outcomes, it tends to be between 190 and 300 grams; and for academic achievement outcomes, it is around 250 grams.[4] We choose a baseline bandwidth of 200 grams to ensure that newborns on either side of the VLBW cutoff are nearly identical, and in Section 6.3 we show that our results are consistent across a wide range of bandwidths. We cluster the standard errors at the gram level (Lee and Card, 2008) and we control for heaping at multiples of 100 grams (Barreca et al., 2011). Some of our robustness checks additionally control for a vector of child and family characteristics, X_{jt}. Finally, we conduct separate analyses for births with gestational ages above and below 32 weeks because the latter are always covered by the medical guidelines for receiving additional medical interventions, irrespective of their VLBW classification (see Section 2).

[4] Since we are primarily interested in the effect of early-life health interventions on siblings, we choose the bandwidth using the sample of focal children with siblings. Bandwidths from this cross-validation technique for the full sample of focal children and for the sample of siblings are provided in Table A1 in the Appendix.

5. Data

Our key data set is the Birth Register, which includes information about the universe of births in Denmark starting from 1970. For each child, the data includes information on the exact date of birth, gender, and plurality. Birth weight is recorded in 250-gram intervals between 1973-1978, in 10-gram intervals in the period 1979-1990, and at the gram level since 1991. Gestational age is added beginning in 1982. Using parental identifiers, we are able to link children to their parents and siblings and determine parity. We can also link this data to other register data that provide information on demographic characteristics, such as maternal age, education, immigration status, and marital status at birth.[5] In addition, we can add information on health outcomes, such as emergency room visits (available between 1995 and 2011), inpatient hospital admissions, and mortality. Finally, we have access to data on academic achievement including 9th grade test scores (available from 2002) and an indicator for high school enrollment by age 19.

5.1. Focal Children with Siblings

As described in Section 4, we first replicate the previous literature investigating the impact of medical technologies on treated children. We restrict our sample of focal children to cohorts born after 1982, when both birth weight and gestational age are recorded in the data, because our empirical strategy exploits differences in medical guidelines for receipt of medical treatments as a function of both of these variables. We include cohorts born up to and including 1993 to ensure that we have access to high school enrolment information for all cohorts. This yields a sample of 772,998 observations. We then exclude 73,385 observations for which

[5] In cases where the father is identified, we have information on the same demographic characteristics for the fathers.

either birth weight or gestational age are missing or incomplete and restrict the sample to those with birth weight within the 1,300-1,700 gram interval. Finally, we restrict the sample to children who have at least one sibling from a different delivery.[6] This yields a sample of 3,677 observations, 2,156 of which have a gestational age of at least 32 weeks and 1,521 a gestational age of less than 32 weeks.

We focus on two outcome domains: health (both short- and long-term) and human capital accumulation. Short-term health outcomes include 28-day and one-year mortality. Our long-term health outcomes include both mental and physical health. For mental health, we focus on diagnosis of intellectual disability before age 5 because previous medical studies link early-life medical treatments to child neuro-development (see, for example, Sinn et al., 2002). For long-term physical health, we include indicators for inpatient hospital admissions and for visits to the emergency room in five-year intervals after birth. We capture human capital accumulation by course specific test scores from 9th grade qualifying exams in both reading and math.[7] The qualifying exams are graded by the teacher and by an

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[6] Appendix Table A2 provides a comparison of children in our analysis sample to all the children born between 1982-1993. We also provide a comparison of children in our sample to all the children with birth weight within our bandwidth. Children with siblings represent 80 percent of the sample of focal children within our bandwidth. Within our bandwidth, observable characteristics are generally similar between the sample of focal children with siblings and the full sample of focal children. There are some small differences suggesting that focal children with siblings are slightly worse off in terms of predicted academic achievement. For that reason, we confirm the robustness of all our results in the full sample of focal children with a birth weight of 1,300-1,700 grams.

[7] Children can be exempt from taking the test if, for example, they have a documented disability. In our 1,300-1,700 gram sample, test scores are missing for approximately 33% of the eligible cohorts. This could be a concern if medical treatments impact test-taking ability. In Section 6.3, we show that the probability of taking the test is smooth across the VLBW cutoff.

external examiner, with the evaluation of the external examiner overruling that of the teacher. To be able to compare grades across cohorts, we standardize them to have zero mean and unit standard deviation within each cohort. In addition to test scores, we also include an indicator for high school enrollment by age 19 as a measure of human capital accumulation. Because of data availability, the estimating sample varies across different outcomes. Panel A of Appendix Table A3 illustrates these differences.

In some of our robustness checks, we control for focal child characteristics (gender, gestational age, parity, plurality, birth year, birth region) and maternal characteristics at birth (age, years of education, marital status and immigrant status).[8]

5.2. Siblings

We define siblings as children born to the same mother from different pregnancies. We include both older and younger siblings because the receipt of additional medical treatments around the VLBW cutoff does not seem to impact future fertility decisions.[9] This results in a sibling sample of 6,389 children born between 1970 and 2010. Of these, 3,594 are siblings of focal children with

[8] Maternal education is missing for a small number of observations (158 observations). We replace these with the median years of education by birth cohort and include an indicator for imputed maternal education.

[9] We find no significant differences across the VLBW cutoff when we estimate our baseline regression using as outcome the probability of having a younger sibling (0.0132, s.e. 0.026), the number of younger siblings (-0.0378, s.e. 0.073), and the birth spacing with younger siblings (0.161, s.e. 0.342).

gestational age of at least 32 weeks and 2,795 are siblings of focal children with gestational age of less than 32 weeks.[10]

As in the case of focal children, our outcome measures capture health and human capital accumulation. For health outcomes, we focus on hospital admissions and ER visits in five-year intervals after the birth of the focal child. For human capital accumulation, we examine 9th grade test scores and enrollment in high school by age 19.[11] Panel B of Appendix Table A3 presents the different samples corresponding to each outcome variable.

Some of our robustness checks, in addition to the focal child characteristics and maternal characteristics, control for sibling characteristics, including gender, parity, plurality, birth weight, and birth year.

6. Results

6.1. Tests of the Validity of the Regression Discontinuity Design

The validity of an RD design rests on the assumption that individuals do not have precise control over the assignment variable. Since women cannot precisely predict the birth weight of their children, the variation in birth weight near the VLBW cutoff is plausibly as good as random (Almond et al., 2010; Bharadwaj et al., 2013). However, the key identification assumption of the RD design could be violated if physicians systematically misreport birth weight, especially in the

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[10] It is possible that a focal child has more than one sibling. Our baseline regressions treat each sibling-focal child pair as an independent observation. This should not be a concern for our identification because parity of the focal child and total family size are relatively smooth across the cutoff.

[11] In our 1,300-1,700 gram sample of test-takers, the maximum age difference between older siblings and focal children is 7.5, indicating that none of the older siblings take the test before the focal children are born.

presence of financial incentives for manipulation (Jürges and Köberlein, 2013; Shigeoka and Fushimi, 2014).

In order to test this assumption, we examine the frequency of births by birth weight within a 200-gram window around the cutoff. Figures 1(a)-(b) plot the distribution of births in the sample of focal children with siblings for those with gestational age above and below 32 weeks, respectively. Figures 1(c)-(d) provide the corresponding distributions for the sibling sample.[12] We use 10-gram bins because birth weight is reported in 10-gram intervals for most of our sample period. Similar to previous studies (Almond et al., 2010; Bharadwaj et al., 2013), we observe reporting heaps at multiples of 50 and 100 grams but there is no evidence of irregular heaping around the VLBW cutoff in any of the samples. We check this more formally by estimating a local-linear regression similar to our baseline model, using the number of births in each birth weight bin as the dependent variable (McCrary, 2008; Almond et al., 2010). We do not find any evidence of a discontinuity in the frequency of births at the VLBW cutoff.[13] These results suggest that birth weight is unlikely to be manipulated in our context.

In the remainder of this section, we check whether there are differences in observable characteristics across the VLBW cutoff. If the RD design is valid, then the observable characteristics should be locally balanced on both sides of the 1,500 gram cutoff. We compare the means of covariates on either side of the

[12] Figure A1 in the Appendix provides corresponding figures for the full sample of focal children.

[13] The estimated coefficients corresponding to Figures 1(a)-(b) are 6.436 (s.e. 9.334) and -0.962 (s.e. 5.435), and to Figures 1(c)-(d) are 15.236 (s.e. 16.544) and -1.123 (s.e. 11.988). The results are robust to using the logarithm of the number of births as the dependent variable instead. In this case, the estimated coefficients in the sample of focal children with siblings are 0.084 (s.e. 0.163) and 0.004 (s.e. 0.130). The estimates in the sibling sample are 0.120 (s.e. 0.181) and 0.016 (s.e. 0.159).

cutoff after controlling for birth weight.[14,15] Table 1 provides these statistics for the sample of focal children with siblings while Table 2 provides a similar analysis for sibling characteristics.[16] In each Table, Columns 1-3 focus on (siblings of) focal children with gestational age of at least 32 weeks and Columns 4-6 on gestational age of less than 32 weeks. The results show that observations just below the VLBW cutoff are generally similar to those just above the VLBW cutoff in terms of maternal characteristics, focal child characteristics, and sibling characteristics. In order to summarize the information provided by individual covariates, we predict each outcome variable using a linear model including the full set of control variables. If there is any selection on observables across the VLBW cutoff, we should observe a discontinuity in these predicted outcomes. As the last panel in each Table shows, predicted outcomes have smooth distributions across the cutoff in all samples.

Overall, the analyses in this section indicate that there is no evidence of manipulation of the running variable around the VLBW cutoff, and that there is no systematic evidence of discontinuities in the observable characteristics of newborns, their mothers and siblings.

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[14] Visual evidence from selected covariates is provided in the Appendix. Appendix Figures A2-A3 present means by birth weight for focal children with gestational age above and below 32 weeks, respectively. Appendix Figures A4-A5 plot the distribution of selected observable characteristics for the siblings of these focal children. Appendix Figures A6 and A7 provide corresponding figures for the sample of all focal children.

[15] This analysis is equivalent to estimating our baseline local-linear regression using the covariates as the dependent variable, with the difference in means below and above the cutoff (i.e., Columns 1-2 and 4-5) representing the coefficient estimate for $VLBW$ and the corresponding p-value clustered at the gram level indicated in Columns 3 and 6.

[16] Appendix Table A4 provides a comparable analysis for the full sample of focal children.

6.2. Baseline Results

Figures 2-5 provide visual evidence on the relationship between birth weight and selected health and academic outcomes of focal children and their siblings.[17] Since focal children with a gestational age of less than 32 weeks receive medical treatments regardless of their birth weight, we plot the distribution of outcomes separately by the gestational age of focal children. Any discontinuity in the outcomes of focal children with less than 32 weeks of gestational age or in the outcomes of their siblings would suggest a violation of the key identification assumptions underlying the RD design.

Focusing on health, Figure 2 shows that among focal children with gestational age of at least 32 weeks, those below the VLBW cutoff have better outcomes both in the short run and in the long run. Figure 3 indicates that these children may also have better long-term academic achievement, particularly in math. In contrast, neither the health nor the academic outcomes of focal children with gestational age of less than 32 weeks exhibit any discontinuities at the 1,500 gram cutoff.

Figures 4-5 turn to the spillover effects of medical treatments on siblings. The graphs show little evidence of spillovers to health outcomes but there are clear positive spillovers to academic achievement outcomes. Siblings of focal children with gestational age of at least 32 weeks and birth weight slightly lower than 1,500 grams have visibly higher test scores in both language and math and they have a higher probability of enrolling in high school by age 19. Distributions of academic achievement outcomes, on the other hand, are relatively smooth across the VLBW threshold for siblings of focal children with gestational age below 32 week.

[17] Appendix Figures A8-A9 plot the distribution of the same outcomes for all focal children.

In Table 3, we present regression results from our baseline models.[18] We again present our findings separately by gestational age of focal children. Columns 1 and 2 focus on focal children outcomes while Columns 3 and 4 focus on their siblings. Each cell reports the estimated coefficient of $VLBW$ from a different regression. Consistent with previous findings in the literature, Panel A of Column 1 shows that, among those with at least 32 weeks of gestation, children who were slightly below the VLBW cutoff have better short-term health relative to those who were just above the VLBW cutoff. For example, our estimates indicate that the probability of death within the first 28 days (1 year) of life is 4.7 (4.8) percentage points lower among VLBW newborns. These are large gains when compared to the average mortality rates of those above the cutoff (6.2 and 7.7 percent, respectively) but they are comparable in magnitude to estimates from previous studies.[19] VLBW children also seem to enjoy better health in the longer term. For example, in Panel B we find that the probability of an intellectual disability diagnosis by age 5 is 1.7 percentage points lower among children slightly below the 1,500 gram cutoff. Similarly, we find that the probability of a hospital admission (an ER visit) between the ages of 6-10 is 8 (17.6) percentage points lower among those just below the cutoff as compared to those just above. These effects correspond to a 50 (44) percent reduction in the probability of a hospital (ER) admission relative to the average child above the cutoff. Finally, focal children who were just below the VLBW cutoff have better academic achievement in the long-run, with 9th grade math test scores higher on average by

[18] Baseline results for the sample of all focal children are provided in Appendix Table A5.

[19] Almond et al. (2010) find that VLBW children have a 1 percentage point lower mortality compared to a mean infant mortality of 5.5 percent just above the cutoff. Bharadwaj et al. (2013) estimate that extra medical treatments reduce 1-year infant mortality in Chile by 4.5 percentage points (mean: 11 percent) and in Norway by 3.1 percentage points (mean: 3.6 percent).

0.38 standard deviations.[20] In contrast to the results in Column 1, Column 2 of Table 3 shows no significant differences in any of the outcomes of those just below the cutoff relative to those just above it in the sample of children with less than 32 weeks of gestation.

Columns 3-4 of Table 3 present the corresponding regression analyses for the sibling sample. Panel B of Column 3 shows that there are no differences in the health outcomes of siblings of focal children who were just below the VLBW cutoff relative to the siblings of focal children who were just above the cutoff. However, we find significant spillovers on academic achievement, with siblings of VLBW newborns with gestational age of at least 32 weeks performing better on all measures of human capital accumulation. For example, siblings of VLBW children have 9th grade language (math) test scores that are on average 0.36 (0.31) standard deviations higher. In addition, they are 9.5 percentage points more likely to enroll in high school by age 19. In contrast, the results in Column 4 indicate that the siblings of focal children with gestational age below 32 weeks have similar health and educational outcomes across the VLBW threshold.

It may be informative to compare the magnitude of the spillover effects of early-life medical interventions to the estimated effects of other policy interventions found in the previous literature. Fredriksson et al. (2013) find that reducing class size in primary school by one student improves test scores at age 16 by 0.023 standard deviations. Dahl and Lochner (2012) estimate that a $1,000 increase in the annual income of disadvantaged families raises children's short-run test scores by 0.061 standard deviations. Turning to the peer effect literature, Carrell and Hoekstra (2010) find that a 10 percentage point increase in the share of disruptive

[20] This estimate is similar to those found by Bharadwaj et al. (2013), who estimate effects of 0.15 standard deviations in Chile and 0.476 standard deviations in Norway.

children in the classroom reduces short-run achievement by 0.05 standard deviations. Using a broader definition of disruption, Kristoffersen et al. (2015) confirm these findings and estimate that having one more disruptive child in the same school-cohort reduces the test scores of Danish students by around 0.02 standard deviations.

When compared to the findings in Fredriksson et al. (2013), the achievement gains in our context are large, corresponding to a 7-student (30 percent) reduction in primary school class size. It is difficult to directly compare our results with studies investigating short-term achievement gains. If we make the (strong) assumption that the effects of early-life medical interventions are cumulative and constant across age, then an average of 9-16 years of exposure for older and younger siblings implies short-run achievement gains of 0.02-0.03 standard deviations. These magnitudes are similar to the contemporaneous effects of having one less disruptive peer and to increasing the annual income of disadvantaged families by about $500.

Overall, we confirm the findings in the previous literature that children who receive additional medical care have better short- and long-term health and higher math test scores in 9th grade. In addition, we find substantial positive spillovers on the academic achievement of siblings. The fact that such gains are not observed among the siblings of children with gestational age below 32 weeks further supports our conjecture that the observed improvements are due (directly or indirectly) to the additional medical treatments received at birth.

6.3. Robustness Checks

In this section we examine the robustness of our baseline estimates to several checks. Since our most novel contribution is investigating spillover effects of medical treatments on the educational outcomes of siblings, we present results for human capital accumulation outcomes using the sibling sample.

In Table 4, we examine the sensitivity of our estimates to the choice of bandwidth and degree of polynomial in the running variable. We present results using selected bandwidths up to 50 percent smaller and larger than our baseline bandwidth of 200 grams.[21] For each bandwidth, we provide results using up to a third degree polynomial in birth weight. We find that our baseline results are consistent across different bandwidths for a given polynomial degree, as well as to the choice of polynomial degree for a given bandwidth.

Table 5 provides additional sensitivity analyses.[22] Column 1 repeats our baseline results for ease of comparison. In Column 2, we check the sensitivity of the results to the inclusion of control variables. If the key assumption in our RD design is satisfied (i.e., birth weight is as good as random around the cutoff), then including additional covariates should not impact the estimates but only increase precision. The results in Column 2 show that this is indeed the case: siblings of focal children who were slightly below the cutoff have significantly better educational outcomes and the magnitudes of the effects are very similar to those in the baseline.

Columns 3-5 turn to the role of heaping. Following Barreca et al. (2011), our main specification controls for heaping at 100-gram intervals. In Column 3, we check whether our results are robust to controlling for heaping at 50-gram

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[21] Appendix Table A6 provides results for all bandwidths between 100-300 grams in 10-gram steps. We present similar results for mortality outcomes and math test scores from the samples of focal children with siblings and of all focal children in Tables A7 and A8, respectively.

[22] Appendix Tables A9 and A10 provide the corresponding results for focal children with siblings and all focal children.

intervals (since our data indicated some heaping at multiples of 50-grams as well). The estimated coefficients of $VLBW$ are virtually identical to our baseline estimates. We next implement the second method suggested by Barreca et al. (2011) and estimate "donut" regressions that exclude observations close to the cutoff. In Column 4, we exclude siblings of focal children who weighed 1,500 grams, while in Column 5 we further exclude siblings where focal children weighed between 1,490 to 1,510 grams. The results are again similar to the main estimates, suggesting that our baseline results are not driven by heaping.

Multiple births are generally characterized by lower birth weight. Indeed, multiple births represent a disproportionate share of focal children within our bandwidth relative to their share in the full population of births (22.16 percent vs. 2.37 percent). But multiple births may also impact siblings through channels other than medical treatments (e.g., family size). Therefore, Column 6 investigates the robustness of our results in a sample of siblings of singletons. We confirm that our baseline results are not sensitive to this sample restriction. This should not be surprising since we do not find any discontinuity in the probability of a multiple birth across the VLBW threshold (see Table 1).

Our baseline results indicate that early-life medical treatments have significant effects on focal child survival. This means that the spillover effects to siblings may also be due to changes in family size. In Column 7 we check if our baseline results still hold when we restrict the sample to siblings of focal children who survive past the first year of life. The results are similar to the baseline with slightly larger magnitudes, indicating again that our results are not due to differences in family size across the VLBW cutoff.

To the extent that the birth weight of children is correlated within the family, it may be that siblings of VLBW children are more likely to be VLBW themselves.

If this is the case, then the observed academic achievement gains among siblings may be due to the early-life medical interventions they themselves received at birth instead of spillovers from the treatments of their siblings. In order to shed light on this issue, we check the sensitivity of our results to excluding VLBW siblings (Column 8) and confirm that our main results are not driven by them.

We also investigate whether our test score results may be biased due to sample selection since students can be exempt from taking the test, for example, because of documented disability. To explore this issue, we examine whether there is any discontinuity at the cutoff in the probability of taking the test. When we estimate the baseline equation using the probability of test taking as the dependent variable, we do not find any evidence of a jump at the VLBW threshold.[23]

Finally, we check whether we observe similar improvements in the educational outcomes of siblings at other points in the distribution of birth weight of the focal child. If the observed gains in academic achievement are indeed driven (directly or indirectly) by the medical treatments received by focal children, then we should not observe systematic discontinuities in the educational outcomes of siblings at other potential cutoffs. We examine cutoffs from 1,100 grams to 2,900 grams, keeping the bandwidth fixed at 200 grams on either side of the cutoff.[24] Results presented in Table 6 indicate that there is no other cutoff where all three educational outcomes of siblings exhibit gains of a magnitude comparable to those observed at the 1,500 gram cutoff. In the few cases where we estimate

[23] The estimated coefficient of $VLBW$ is 0.032 (s.e. 0.050) for the probability of taking the math test and 0.019 (s.e. 0.051) for the probability of taking the language test. The corresponding coefficients in the sample of focal children with siblings are -0.054 (s.e. 0.071) and -0.021 (s.e. 0.076), and in the full sample of focal children they are -0.052 (s.e. 0.067) and -0.030 (s.e. 0.070).

[24] The corresponding results for the samples of focal children with siblings and all focal children are provided in Appendix Tables A11 and A12, respectively.

significant differences in educational outcomes, the effects are much smaller than at the 1,500 gram cutoff and/or have the “wrong” sign. In addition, we do not observe any discontinuities in focal child mortality at other points in the birth weight distribution (see Appendix Tables A11-12). Combined with the absence of discontinuities at the VLBW cutoff in the educational outcomes of siblings of focal children with gestational age of less than 32 weeks, these findings strongly suggest that the observed spillover effects are due to the (indirect or direct) impact of medical treatments provided to VLBW focal children.

6.4. Potential Mechanisms

In this section, we investigate the role of several mechanisms that may explain our findings. Our baseline results show that early-life interventions provided to VLBW children improve the health outcomes of treated children, but the physical health of siblings is comparable across the VLBW cutoff. This indicates that the observed spillover effects are unlikely to be driven by siblings’ direct exposure to additional medical care.

In Table 7, we examine whether these treatments impact resources within the family. We construct measures of parental and total income as well as parental labor market participation (an indicator for being employed at least one day during the year, average number of full-time working days per year, total number of maternity leave days) in five-year intervals after the birth of the focal child. We do not find significant differences in any of the outcomes across the VLBW cutoff, suggesting that differences in total household resources are unlikely to explain the observed spillover effects on siblings.

In Table 8, we study whether early-life medical treatments to VLBW children impact the family environment. Motivated by the literature linking child health to family dissolution and parental health, we investigate effects on divorce and parental mental health (proxied by the use of antidepressants). We find no significant difference in the likelihood of family dissolution across the VLBW cutoff ten years after the birth of the focal child. However, we do find some evidence of improved maternal mental health soon after the birth of the focal child that dissipates as the child ages.[25]

In the absence of time-use survey data, we are not able to investigate how early-life medical treatments may shape parent-child and sibling interactions. To the extent that better mental health leads to better parent-child interactions, this could be one of the main channels behind our results. In order to shed some light on the quality of peer interactions, we study in Table 9 the spillover effects in subsamples defined by sibship characteristics. Previous literature in psychology and in economics finds that girls, younger siblings, and siblings of the same sex are more likely to be affected by the interaction with their siblings (e.g., Furman and Buhrmester, 1985; Dunn, 2007; Oettinger, 2000; Fletcher et al., 2012). Consistent with this literature, we find evidence of much larger spillover effects on the academic achievement of girls, younger siblings, and siblings of the same sex, particularly in math and in the probability of high school enrollment. This provides some indirect evidence that improved quality of sibling interactions may be one of the drivers of improved sibling academic achievement.

Finally, we note that changes in intra-household allocation may be another mechanism behind our results. While we cannot rule out parental compensating behavior, our findings of heterogeneous effects across different subsets of sibship characteristics indicate that this is likely not the most relevant channel.

[25] We have access to prescription drug data beginning from 1995 so we are unable to construct measures of antidepressant use for the first two years after the birth of any focal child in our sample.

Overall, the results in this section rule out changes in total household resources and intra-household resource allocation as the main drivers of observed spillover effects. Combined with evidence of improved focal child mental health, they instead suggest that improved interactions among family members may be an important mechanism behind our results.

7. Conclusions

In this paper, we investigate the spillover effects of medical treatments received by VLBW children on their siblings. Using register data from Denmark, we first confirm the findings in the previous literature documenting that children who weigh slightly less than 1,500 grams are more likely to survive past the first year of life, to enjoy better health in the long-run, and to have better educational outcomes (measured in our data as 9th grade math scores). While we do not find any spillover effects on the health outcomes of siblings of these children, we find substantial positive spillovers on educational outcomes. In particular, our results indicate that siblings of focal children who were slightly below the VLBW cutoff have better 9th grade language and math test scores, as well as higher probability of enrolling in a high school by age 19. We also provide evidence suggesting that improved quality of parent-child and sibling interactions may be an important pathway behind the observed spillover effects.

During the past few decades, medical spending for the very young increased substantially faster than spending for the average individual (Cutler and Meara, 1998). As medical expenditures keep increasing, understanding the efficacy of early-life medical interventions becomes even more important. Overall, our results suggest that medical treatments for VLBW children may have externalities to other family members that raise their net benefits. Our results also have implications for studies on the effects of early-life health endowments using sibling fixed-effects estimators. The fact that we find substantial positive spillovers on the siblings of treated children suggests that within-sibling comparisons of achievement gains may underestimate the true impact of initial health endowments on later-life outcomes.

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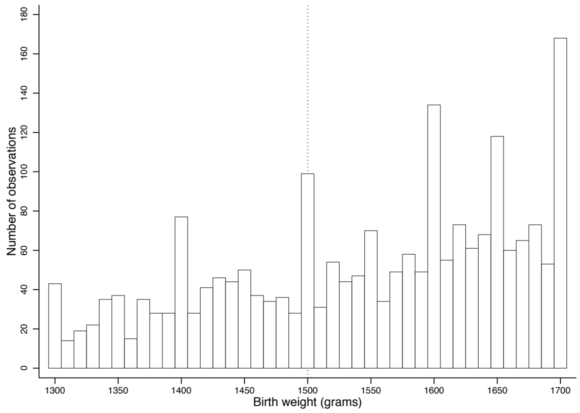
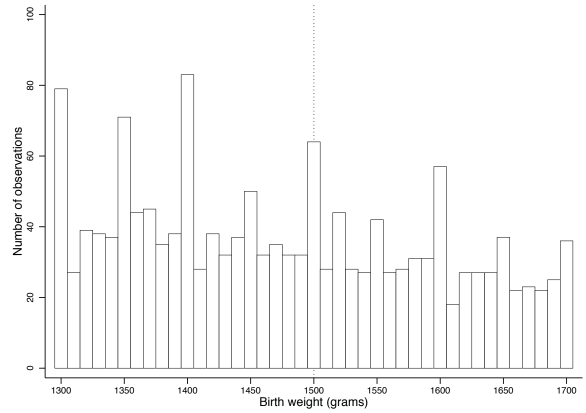
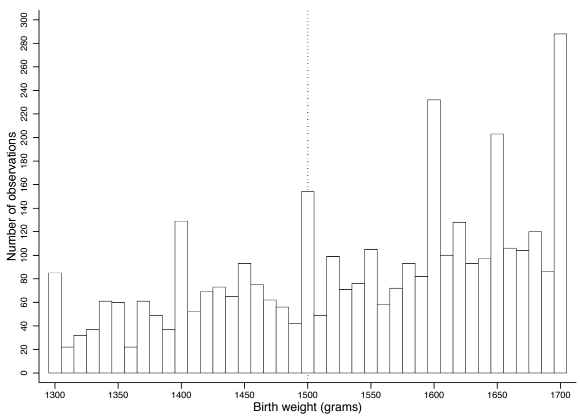


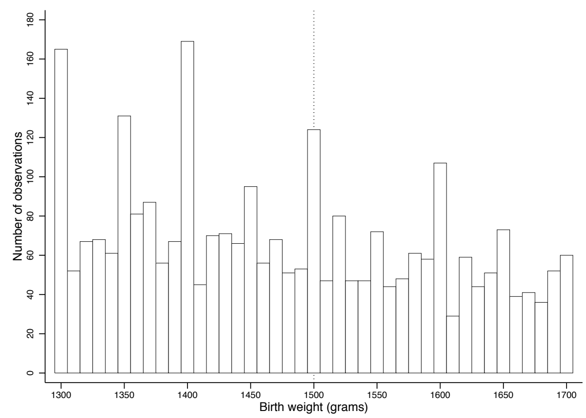
(a) Focal children with siblings, gestational age ≥ 32 weeks



(b) Focal children with siblings, gestational age < 32 weeks

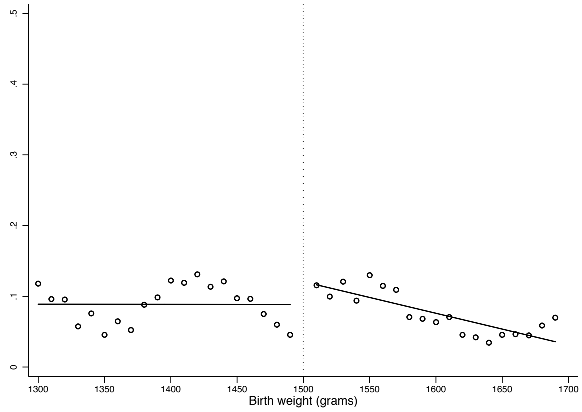


(c) Siblings of focal children with gestational age ≥ 32 weeks

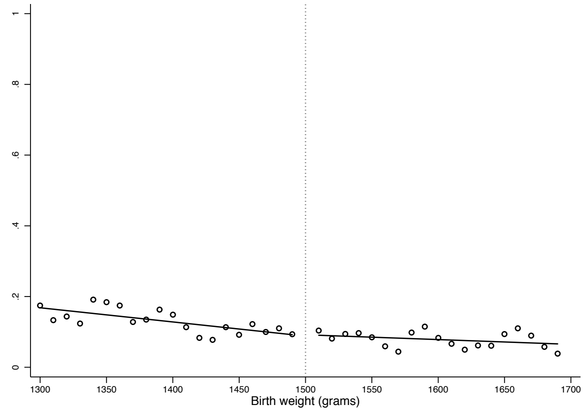


(d) Siblings of focal children with gestational age < 32 weeks

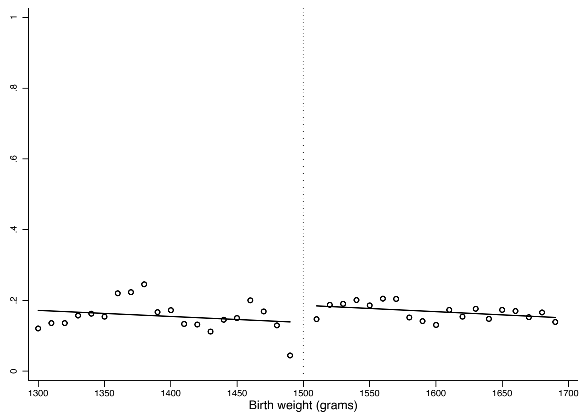
Figure 1: Frequency of births around the VLBW cutoff



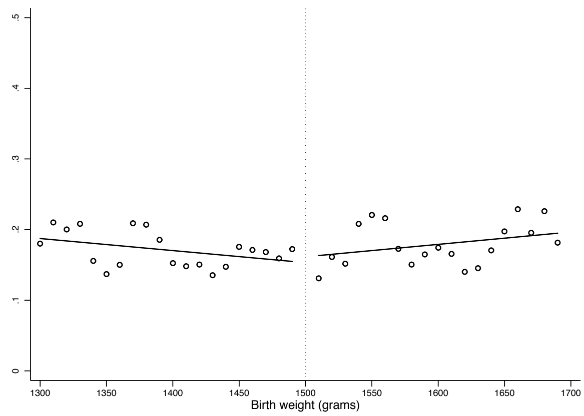
(a) 1-year mortality,
gestational age ≥ 32 weeks



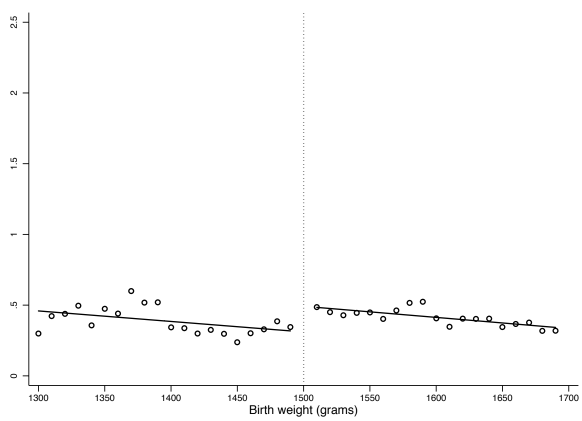
(b) 1-year mortality,
gestational age < 32 weeks



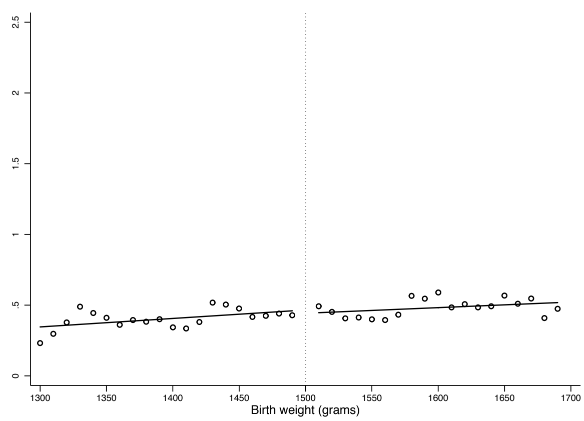
(c) Hospital admission, focal child age 6-10,
gestational age ≥ 32 weeks



(d) Hospital admission, focal child age 6-10,
gestational age < 32 weeks



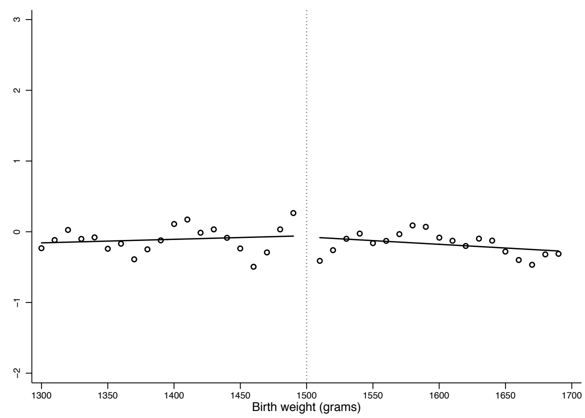
(e) ER admission, focal child age 6-10,
gestational age ≥ 32 weeks



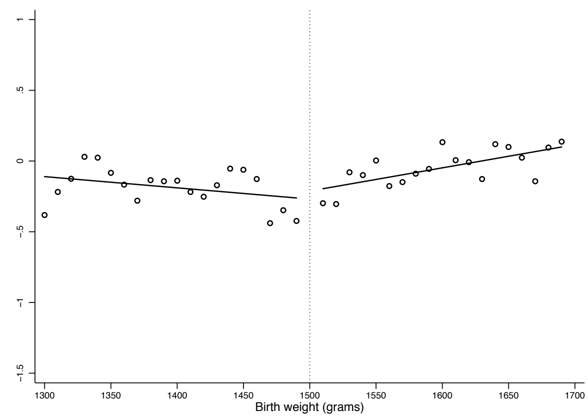
(f) ER admission, focal child age 6-10,
gestational age < 32 weeks

Figure 2: Distribution of health outcomes around VLBW cutoff, focal children with siblings

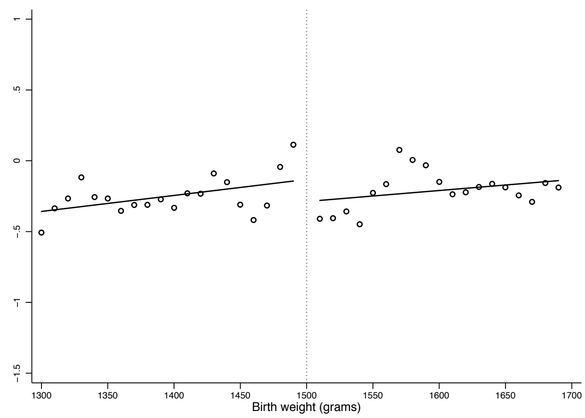
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



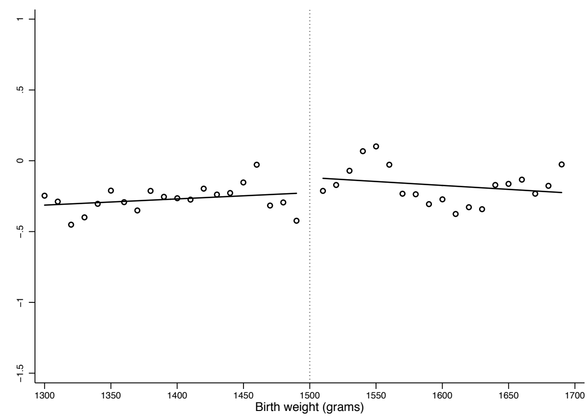
(a) Language test score,
gestational age ≥ 32 weeks



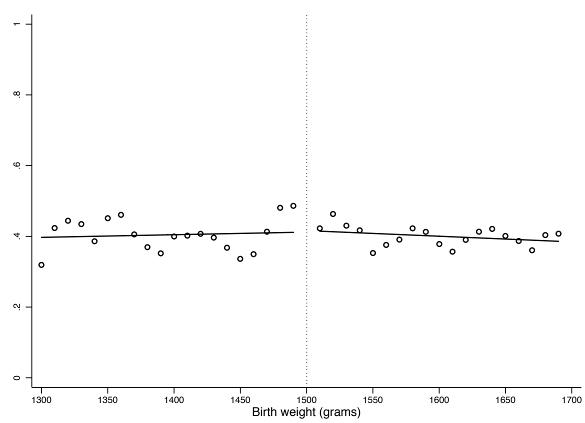
(b) Language test score,
gestational age < 32 weeks



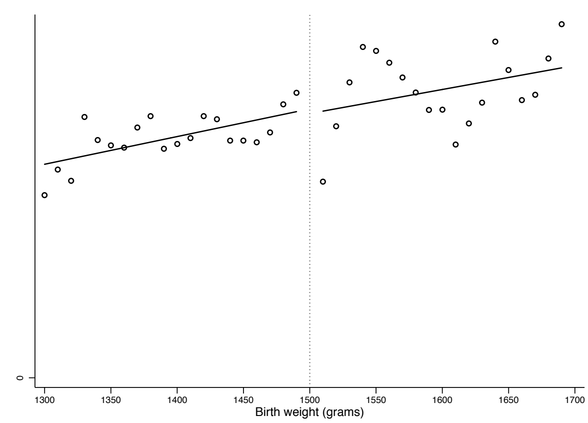
(c) Math test score,
gestational age ≥ 32 weeks



(d) Math test score,
gestational age < 32 weeks



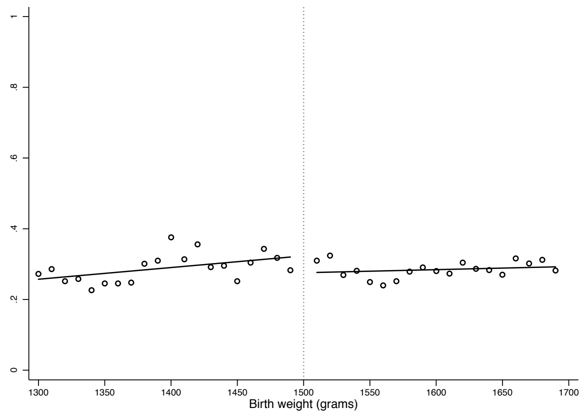
(e) High school enrollment,
gestational age ≥ 32 weeks



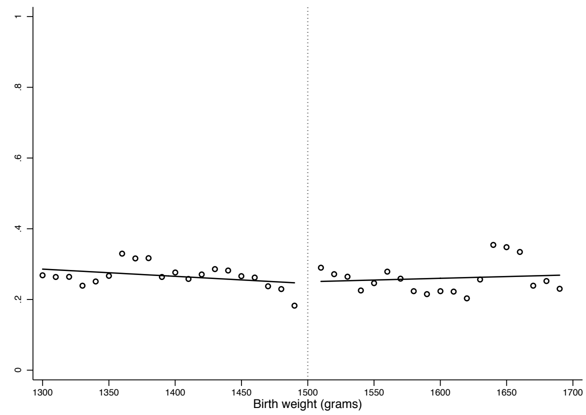
(f) High school enrollment,
gestational age < 32 weeks

Figure 3: Distribution of academic achievement outcomes around VLBW cutoff, focal children with siblings

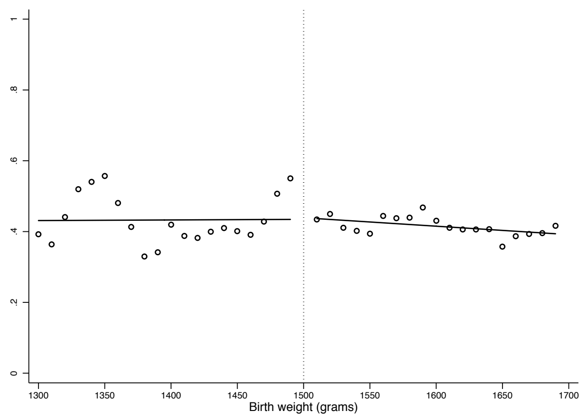
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



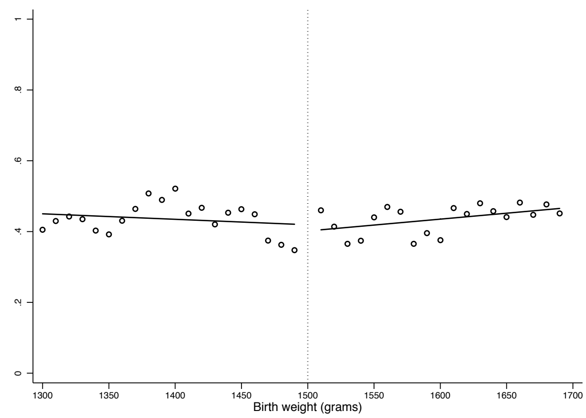
(a) Hospital admission, focal child age 6-10, gestational age ≥ 32 weeks



(b) Hospital admission, focal child age 6-10, gestational age < 32 weeks



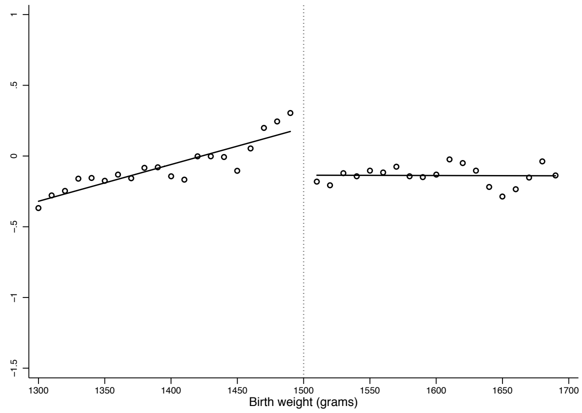
(c) ER admission, focal child age 6-10, gestational age ≥ 32 weeks



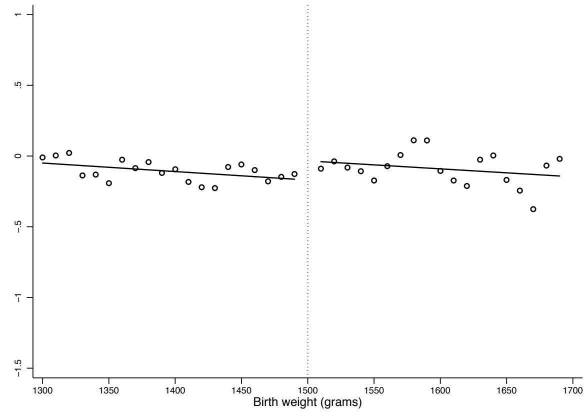
(d) ER admission, focal child age 6-10, gestational age < 32 weeks

Figure 4: Distribution of health outcomes around VLBW cutoff, siblings

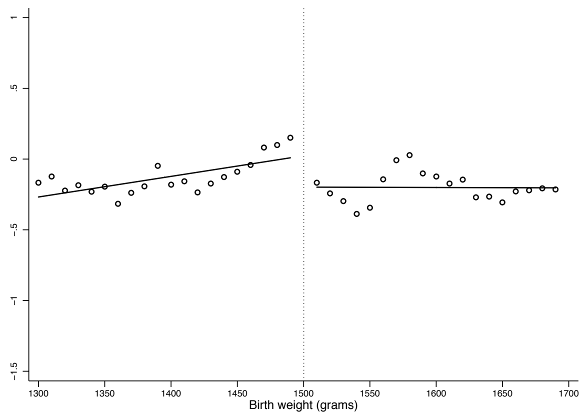
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



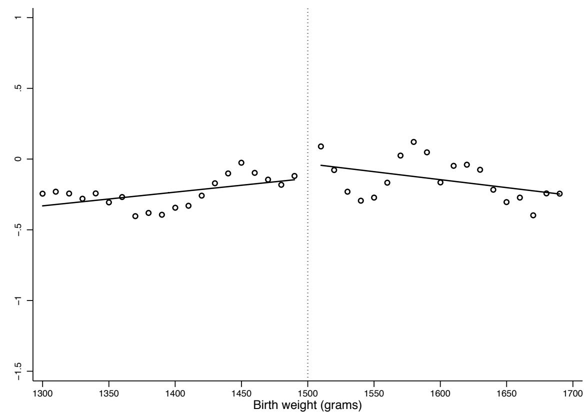
(a) Language test score,
gestational age ≥ 32 weeks



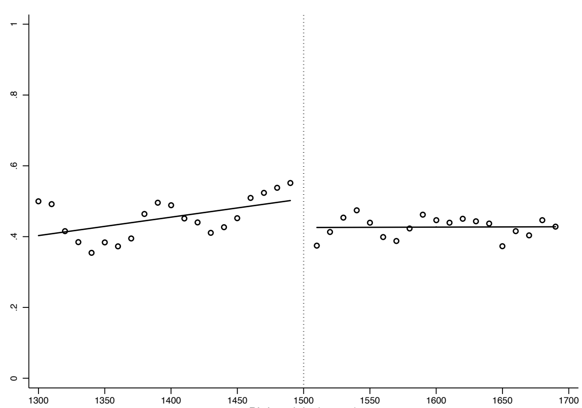
(b) Language test score,
gestational age < 32 weeks



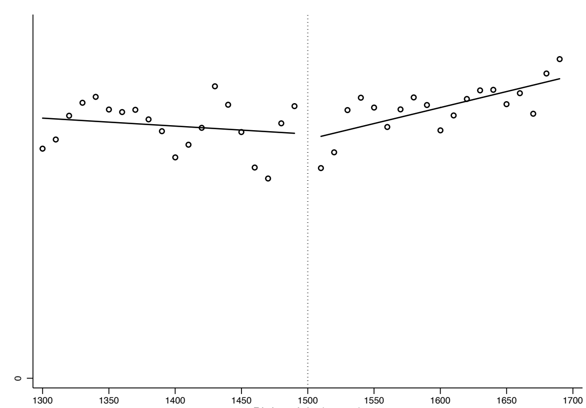
(c) Math test score,
gestational age ≥ 32 weeks



(d) Math test score,
gestational age < 32 weeks



(e) High school enrollment,
gestational age ≥ 32 weeks



(f) High school enrollment,
gestational age < 32 weeks

Figure 5: Distribution of academic achievement outcomes around VLBW cutoff, siblings

Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.

Table 1: Distribution of covariates across the VLBW cutoff, focal children with siblings

	Gestational age ≥ 32 weeks			Gestational age < 32 weeks		
	Birth weight < 1,500g	Birth weight ≥ 1,500g	p-value	Birth weight < 1,500g	Birth weight ≥ 1,500g	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
A. Parental characteristics						
Mother's education (years)	11.189	11.311	0.719	11.213	10.997	0.339
Mother's age at birth of focal child	28.566	27.595	0.067	27.969	27.794	0.739
Immigrant mother	0.051	0.065	0.623	0.063	0.055	0.750
Married parents	0.551	0.525	0.699	0.459	0.489	0.579
B. Child characteristics						
Birth order	2.083	1.844	0.049	2.007	1.979	0.797
Multiple birth	0.247	0.208	0.312	0.139	0.180	0.200
Gender: Male	0.425	0.441	0.804	0.622	0.603	0.657
Gestational age	33.689	33.978	0.110	30.210	30.170	0.712
C. Predicted outcomes						
Mortality, 28-days	0.038	0.037	0.137	0.060	0.060	0.923
Mortality, 1-year	0.045	0.044	0.129	0.070	0.070	0.876
Intellectual disability diagnosis by age 5	0.0048	0.0046	0.280	0.0066	0.0066	0.875
Hospital admission, focal child age 0-5	0.645	0.608	0.422	0.612	0.653	0.410
Hospital admission, focal child age 6-10	0.132	0.127	0.500	0.145	0.151	0.427
Hospital admission, focal child age 11-15	0.119	0.113	0.398	0.118	0.125	0.400
ER admission, focal child age 6-10	0.354	0.343	0.502	0.350	0.362	0.478
ER admission, focal child age 11-15	0.349	0.330	0.443	0.333	0.352	0.433
Language test score	-0.063	-0.054	0.851	-0.161	-0.169	0.816
Math test score	-0.153	-0.134	0.689	-0.198	-0.205	0.830
High school enrollment	0.490	0.494	0.880	0.394	0.392	0.915
Observations	697	1,459		852	669	

Notes: Sample of focal children with siblings, with birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell in Columns 1-2 and 4-5 represents the mean of the corresponding variable in the row after controlling for birth weight. Columns 3 and 6 present the *p*-value for differences in means clustered at the gram level.

Table 2: Distribution of covariates across the VLBW cutoff of focal children, siblings

	Gestational age of focal child ≥ 32 weeks			Gestational age of focal child < 32 weeks		
	Birth weight < 1,500g	Birth weight ≥ 1,500g	p-value	Birth weight < 1,500g	Birth weight ≥ 1,500g	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
A. Child characteristics						
Birth order	2.210	2.251	0.704	2.236	2.140	0.351
Multiple birth	0.034	0.012	0.192	0.029	0.012	0.350
Gender: Male	0.481	0.494	0.773	0.506	0.552	0.212
Birth weight	2,841	2,944	0.074	2,879	3,023	0.016
VLBW	0.068	0.051	0.350	0.065	0.040	0.221
Age difference (older siblings)	6.775	6.838	0.909	6.394	6.011	0.617
Age difference (younger siblings)	4.909	5.273	0.353	5.962	5.909	0.938
B. Predicted outcomes						
Hospital admission, focal child age 0-5	0.360	0.352	0.742	0.380	0.380	0.972
Hospital admission, focal child age 6-10	0.278	0.273	0.652	0.284	0.287	0.784
Hospital admission, focal child age 11-15	0.220	0.209	0.170	0.217	0.219	0.825
ER admission, focal child age 6-10	0.407	0.402	0.696	0.406	0.416	0.381
ER admission, focal child age 11-15	0.398	0.382	0.326	0.391	0.402	0.476
Language test score	-0.139	-0.136	0.965	-0.178	-0.188	0.848
Math test score	-0.206	-0.195	0.859	-0.234	-0.208	0.673
High school enrollment	0.319	0.334	0.727	0.295	0.281	0.722
Observations	1,182	2,412		1,579	1,216	

Notes: Sample of siblings of focal children with birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell in Columns 1-2 and 4-5 represents the mean of the corresponding variable in the row after controlling for birth weight. Columns 3 and 6 present the *p*-value for differences in means clustered at the gram level.

Table 3: Baseline regressions

	Focal children with siblings		Siblings	
	Gestational age		Gestational age	
	≥ 32 weeks	< 32 weeks	≥ 32 weeks	< 32 weeks
	(1)	(2)	(3)	(4)
A. Short-term health				
28-day mortality	-0.047**	-0.019		
	(0.023)	(0.031)		
Mean outcome, non-VLBW focal children	0.062	0.072		
Observations	2,156	1,521		
1-year mortality	-0.048*	-0.008		
	(0.026)	(0.036)		
Mean outcome, non-VLBW focal children	0.077	0.085		
Observations	2,156	1,521		
B. Long-term health				
Intellectual disability diagnosis by age 5	-0.017*	0.020		
	(0.010)	(0.013)		
Mean outcome, non-VLBW focal children	0.012	0.003		
Observations	2,156	1,521		
Ever admitted to hospital, focal child age 0-5	0.063	-0.009	0.050	-0.006
	(0.051)	(0.075)	(0.045)	(0.056)
Mean outcome, non-VLBW focal children	0.611	0.650	0.352	0.339
Observations	2,156	1,521	3,594	2,795
Ever admitted to hospital, focal child age 6-10	-0.080*	-0.026	0.046	-0.022
	(0.044)	(0.040)	(0.051)	(0.041)
Mean outcome, non-VLBW focal children	0.161	0.184	0.275	0.266
Observations	1,960	1,337	3,594	2,795
Ever admitted to hospital, focal child age 11-15	-0.026	-0.008	0.015	0.000
	(0.033)	(0.035)	(0.038)	(0.032)
Mean outcome, non-VLBW focal children	0.127	0.132	0.232	0.231
Observations	1,960	1,334	3,594	2,795
ER admission, focal child age 6-10	-0.176**	0.050	0.059	0.001
	(0.072)	(0.067)	(0.063)	(0.064)
Mean outcome, non-VLBW focal children	0.404	0.451	0.422	0.444
Observations	782	609	1,429	1,264
ER admission, age 11-15	-0.070	-0.084	0.022	0.008
	(0.064)	(0.071)	(0.043)	(0.044)
Mean outcome, non-VLBW focal children	0.350	0.347	0.416	0.382
Observations	1,619	1,122	2,964	2,375

Table 3: Baseline regressions (cont'd)

	Focal children		Siblings	
	Gestational age		Gestational age	
	≥ 32 weeks	< 32 weeks	≥ 32 weeks	< 32 weeks
	(1)	(2)	(3)	(4)
C. Academic achievement				
Language test score	0.230	-0.134	0.358***	-0.031
	(0.204)	(0.139)	(0.093)	(0.099)
Mean outcome, non-VLBW focal children	-0.185	-0.044	-0.154	-0.065
Observations	939	697	1,511	1,130
Math test score	0.382***	-0.229	0.313**	-0.067
	(0.143)	(0.159)	(0.151)	(0.107)
Mean outcome, non-VLBW focal children	-0.259	-0.135	-0.211	-0.117
Observations	926	703	1,517	1,139
High school enrollment	0.007	0.009	0.095**	0.041
	(0.052)	(0.057)	(0.043)	(0.067)
Mean outcome, non-VLBW focal children	0.390	0.419	0.438	0.451
Observations	2,156	1,521	2,658	2,055

Notes: Sample of focal children with birth weight within a 200g bandwidth around the 1,500g cutoff (columns 1-2) and of their siblings (columns 3-4). Gestational age in column headings refers to focal children. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table 4: Robustness to choice of bandwidth and degree of polynomial in birth weight, siblings of focal children with gestational age of at least 32 weeks

	Bandwidth = 100 grams			Bandwidth = 150 grams			Bandwidth = 200 grams			Bandwidth = 250 grams			Bandwidth = 300 grams		
	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Language test score	0.499***	0.628***	0.524	0.439***	0.532***	0.483**	**0.358*****	0.529***	0.558***	0.284***	0.480***	0.536***	0.242***	0.425***	0.527***
	(0.146)	(0.214)	(0.339)	(0.106)	(0.172)	(0.208)	**(0.093)**	(0.143)	(0.199)	(0.086)	(0.119)	(0.177)	(0.083)	(0.112)	(0.155)
Observations	754	754	754	1,116	1,116	1,116	**1,511**	1,511	1,511	1,884	1,884	1,884	2,416	2,416	2,416
Math test score	0.442*	0.032	-0.458	0.376**	0.461	0.318	**0.313****	0.470*	0.452	0.271**	0.418**	0.503*	0.225**	0.409**	0.447*
	(0.249)	(0.318)	(0.346)	(0.186)	(0.282)	(0.321)	**(0.151)**	(0.247)	(0.305)	(0.127)	(0.209)	(0.282)	(0.114)	(0.186)	(0.257)
Observations	758	758	758	1,120	1,120	1,120	**1,517**	1,517	1,517	1,887	1,887	1,887	2,419	2,419	2,419
High school enrollment	0.161**	0.233**	0.224	0.113**	0.137*	0.109	**0.095****	0.131**	0.119	0.069*	0.137**	0.125	0.054	0.124**	0.136**
	(0.067)	(0.099)	(0.142)	(0.051)	(0.078)	(0.095)	**(0.043)**	(0.064)	(0.089)	(0.039)	(0.054)	(0.076)	(0.038)	(0.049)	(0.068)
Observations	1,363	1,363	1,363	1,989	1,989	1,989	**2,658**	2,658	2,658	3,383	3,383	3,383	4,291	4,291	4,291

Notes: Sample of siblings of focal children with gestational age of at least 32 weeks and birth weight within a bandwidth around the 1,500g cutoff indicated in panel headings. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table 5: Additional robustness checks, siblings of focal children with gestational age of at least 32 weeks

	Baseline	Including controls	Control for heaping at 50g	Donut sample: Excluding 1,500g	Donut sample: Excluding 1,490g-1,510g	Excluding siblings of focal multiple births	Only siblings of surviving focal children	Excluding VLBW siblings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Language test score	0.358***	0.347***	0.362***	0.352***	0.339***	0.349***	0.412***	0.372***
	(0.093)	(0.100)	(0.091)	(0.100)	(0.115)	(0.108)	(0.096)	(0.098)
Mean outcome	-0.154	-0.155	-0.154	-0.156	-0.154	-0.154	-0.163	-0.151
Observations	1,511	1,510	1,511	1,443	1,408	1,288	1,330	1,457
Math test score	0.313**	0.324**	0.316**	0.284*	0.326*	0.305*	0.380**	0.329**
	(0.151)	(0.129)	(0.150)	(0.158)	(0.189)	(0.158)	(0.149)	(0.142)
Mean outcome	-0.211	-0.213	-0.211	-0.207	-0.207	-0.204	-0.204	-0.205
Observations	1,517	1,516	1,517	1,449	1,414	1,290	1,333	1,466
High school enrollment	0.095**	0.117***	0.094**	0.109**	0.084	0.132***	0.111**	0.096**
	(0.043)	(0.037)	(0.043)	(0.047)	(0.051)	(0.046)	(0.049)	(0.045)
Mean outcome	0.438	0.438	0.438	0.433	0.435	0.433	0.431	0.451
Observations	2,658	2,658	2,658	2,531	2,473	2,157	2,343	2,516

Notes: Sample of siblings of focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. In addition, the specification in column 2 includes controls for focal child characteristics (gestational age and indicators for gender, parity, plurality, birth year, and birth region), maternal characteristics (age, years of education, and marital status at delivery), and older sibling characteristics (birth weight and indicators for gender, parity, plurality, and birth year), and the specification in column 3 includes controls for heaping at 50g intervals. The samples in columns 4 and 5 exclude siblings of focal children with birth weight of exactly 1,500g or between 1,490-1,510g, respectively. The samples in columns 6-8 exclude siblings of focal children from multiple births, siblings of focal children who do not survive past the first year of life, and siblings who are VLBW themselves, respectively. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table 6: Placebo regressions at different cutoffs, siblings of focal children with gestational age of at least 32 weeks

	Cutoff									
	1,100g	1,300g	**1,500g**	1,700g	1,900g	2,100g	2,300g	2,500g	2,700g	2,900g
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Language test score	0.144	0.119	**0.358*** **	0.091	0.031	-0.053	-0.101**	0.037	0.021	0.003
	(0.257)	(0.176)	**(0.093)**	(0.103)	(0.069)	(0.049)	(0.039)	(0.037)	(0.023)	(0.015)
Mean outcome	-0.160	-0.073	**-0.154**	-0.134	-0.133	-0.140	-0.143	-0.133	-0.123	-0.094
Observations	380	789	**1,511**	2,770	4,879	8,322	14,846	27,312	50,161	86,961
Math test score	0.016	0.085	**0.313** **	-0.048	0.052	-0.037	-0.075**	-0.002	0.046*	0.046**
	(0.338)	(0.162)	**(0.151)**	(0.056)	(0.059)	(0.060)	(0.035)	(0.024)	(0.024)	(0.020)
Mean outcome	-0.099	-0.131	**-0.211**	-0.170	-0.175	-0.211	-0.211	-0.204	-0.169	-0.128
Observations	377	797	**1,517**	2,763	4,878	8,342	14,874	27,406	50,311	87,208
High school enrollment	0.052	0.068	**0.095** **	0.007	0.040	-0.009	-0.015	0.007	-0.000	-0.003
	(0.098)	(0.056)	**(0.043)**	(0.038)	(0.025)	(0.024)	(0.023)	(0.015)	(0.008)	(0.008)
Mean outcome	0.448	0.461	**0.438**	0.436	0.445	0.440	0.446	0.462	0.482	0.508
Observations	599	1,351	**2,658**	4,978	8,766	14,743	25,513	45,371	80,318	135,169

Notes: Sample of siblings of focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the cutoff indicated in the column heading. Each cell represents the coefficient of an indicator variable for birth weight less than the cutoff from a separate regression of the outcome variable listed in the row. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table 7: Effects on family resources, focal children with siblings and with gestational age of at least 32 weeks

	(1)	(2)	(3)	(4)	(5)	(6)
	Mother's income, by age of focal child		Father's income, by age of focal child		Total family income, by age of focal child	
	0-5 years	6-10 years	0-5 years	6-10 years	0-5 years	6-10 years
VLBW	3756.203	6942.640	15776.096	30696.020	17785.016	35986.796
	(12277.602)	(13327.179)	(17455.764)	(19708.082)	(26211.913)	(28024.166)
Mean outcome	112,186	141,310	218,813	235,205	324,799	365,282
Observations	2,152	2,122	2,109	2,071	2,154	2,142
	Mother's employment, by age of focal child		Mother's days worked, by age of focal child		Maternity leave	
	0-5 years	6-10 years	0-5 years	6-10 years	(days)	
VLBW	-0.054	0.009	3.653	5.115	13.866	
	(0.037)	(0.034)	(10.972)	(11.718)	(11.263)	
Mean outcome	0.874	0.841	120.663	145.480	152.017	
Observations	2,151	2,119	2,151	2,119	1,326	
	Father's employment, by age of focal child		Father's days worked, by age of focal child			
	0-5 years	6-10 years	0-5 years	6-10 years		
VLBW	-0.041	0.030	-0.683	7.487		
	(0.037)	(0.049)	(11.587)	(11.574)		
Mean outcome	0.914	0.868	183.093	183.045		
Observations	2,108	2,070	2,108	2,070		

Notes: Sample of focal children with siblings and with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table 8: Effects on family environment, focal children with siblings and with gestational age of at least 32 weeks

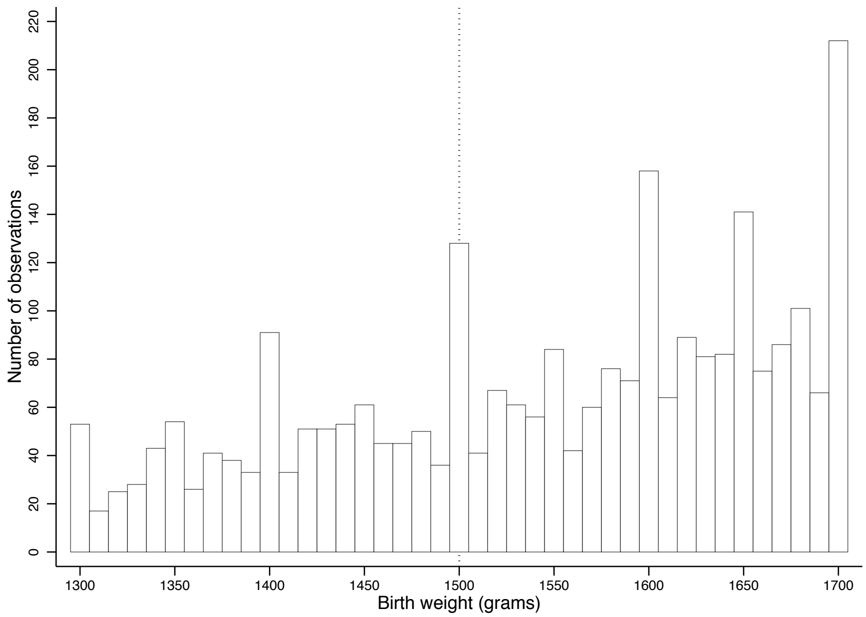
	Divorce by age 10 of focal child	Mother's use of antidepressants, by age of focal child			Father's uses antidepressants, by age of focal child		
		2-5 years	6-10 years	11-15 years	2-5 years	6-10 years	11-15 years
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VLBW	0.073	-0.051*	-0.031	-0.009	0.011	0.027	0.008
	(0.050)	(0.026)	(0.021)	(0.021)	(0.032)	(0.022)	(0.036)
Mean outcome	0.295	0.045	0.046	0.061	0.033	0.045	0.067
Observations	2,117	689	1,585	2,155	669	1,555	2,117

Notes: Sample of focal children with siblings and with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

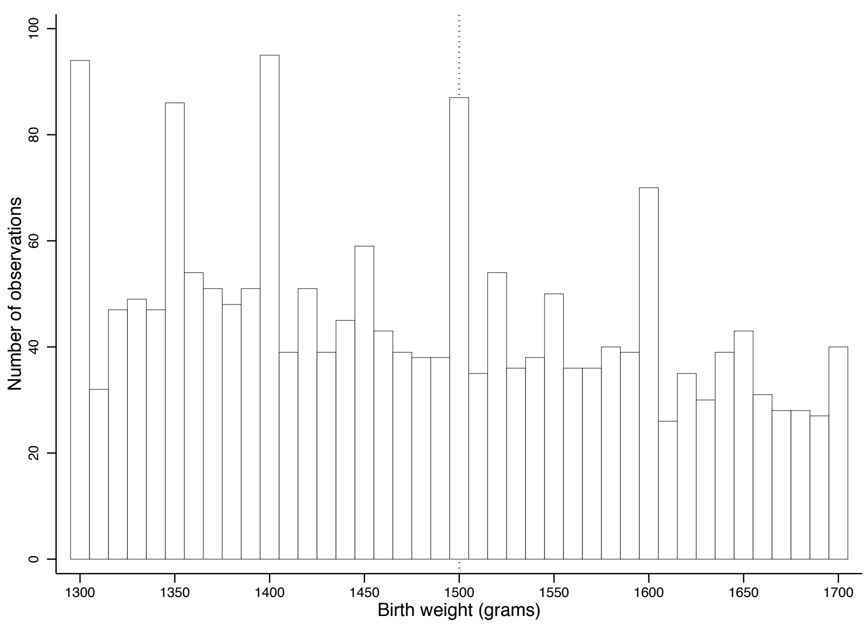
Table 9: Heterogeneous effects by sibship, siblings of focal children with gestational age of at least 32 weeks

	Sibling gender		Sibling birth order		Sibship gender composition	
	Girl	Boy	Younger	Older	Different gender	Same gender
	(1)	(2)	(3)	(4)	(5)	(6)
Language test score	0.286*	0.370***	0.393***	0.197	0.335**	0.387***
	(0.146)	(0.121)	(0.121)	(0.400)	(0.142)	(0.133)
Mean outcome	0.018	-0.329	-0.161	-0.122	-0.124	-0.184
Observations	766	745	1,266	245	741	770
Math test score	0.519**	0.095	0.321**	0.215	0.169	0.455**
	(0.198)	(0.170)	(0.155)	(0.275)	(0.188)	(0.178)
Mean outcome	-0.287	-0.138	-0.233	-0.100	-0.195	-0.227
Observations	758	759	1,271	246	742	775
High school enrollment	0.135**	0.057	0.152**	0.082	0.021	0.177***
	(0.066)	(0.056)	(0.061)	(0.063)	(0.052)	(0.045)
Mean outcome	0.523	0.360	0.464	0.419	0.426	0.451
Observations	1273	1385	1,125	1,533	1,343	1,315

Notes: Sample of siblings of focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

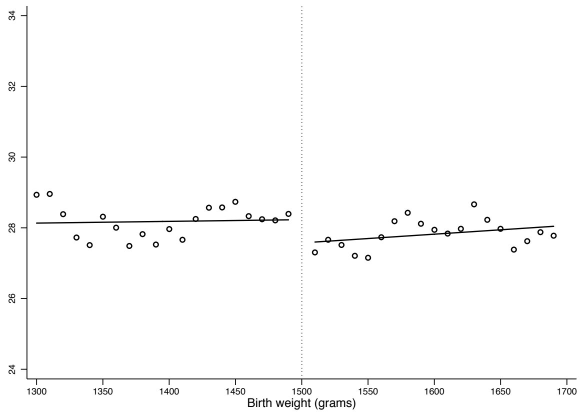


(a) Gestational age ≥ 32 weeks

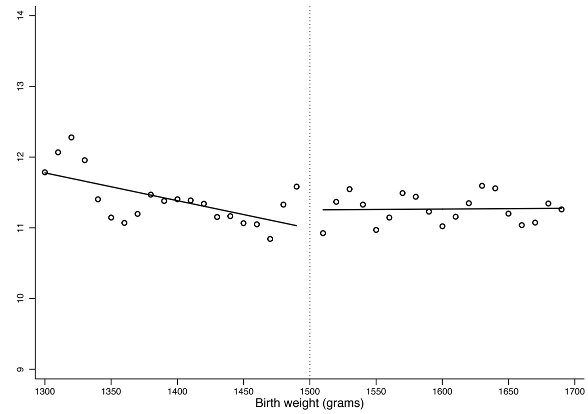


(b) Gestational age < 32 weeks

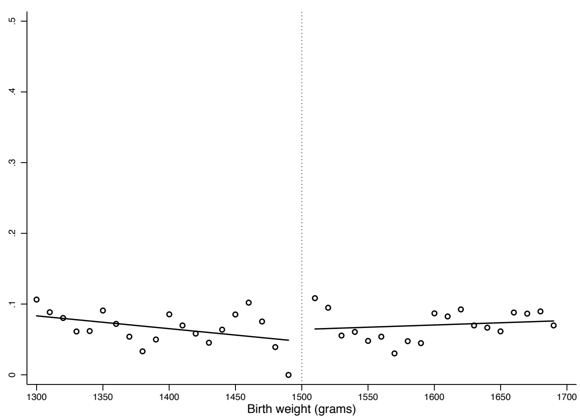
Appendix Figure A1: Frequency of births around the VLBW cutoff, all focal children



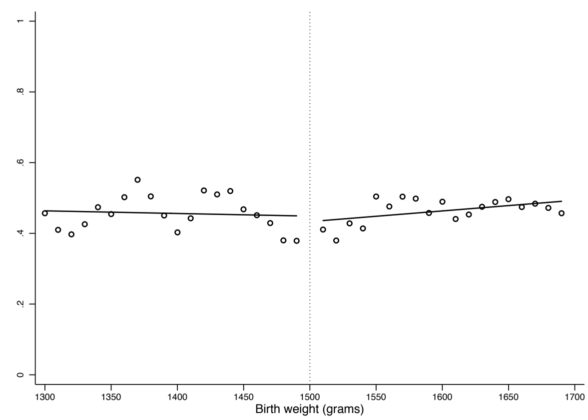
(a) Maternal age at birth of focal child



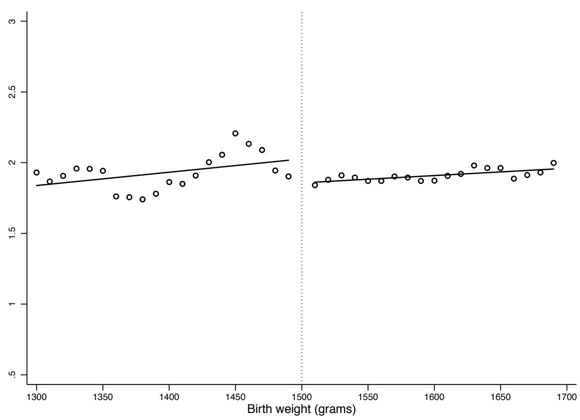
(b) Maternal years of education



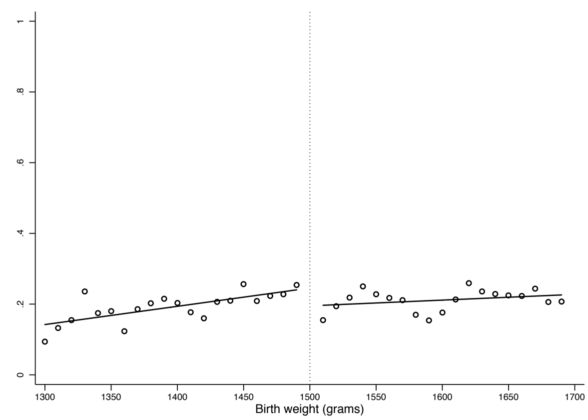
(c) Maternal immigrant status



(d) Focal child male



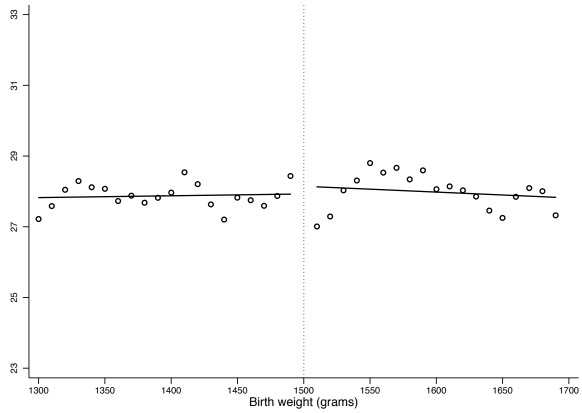
(e) Focal child parity



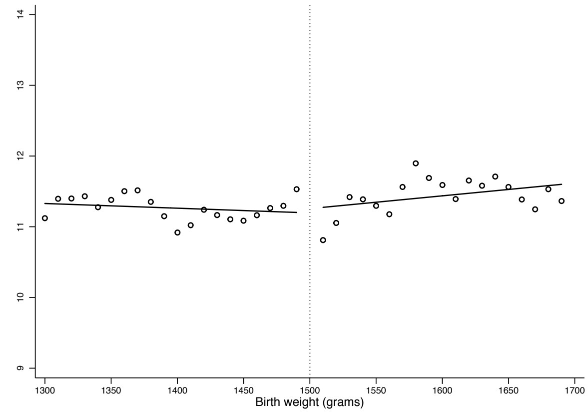
(f) Focal child plurality

Figure A2: Distribution of selected covariates around VLBW cutoff, focal children with siblings, gestational age ≥ 32 weeks

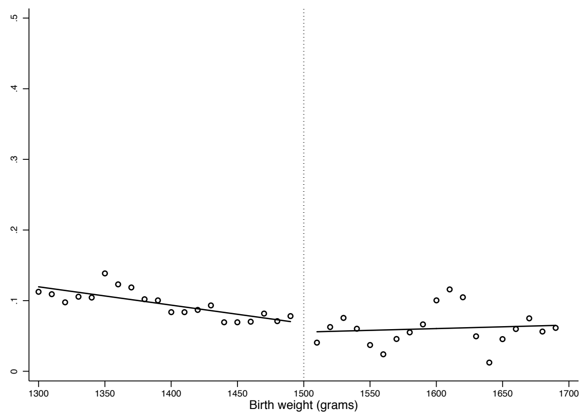
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



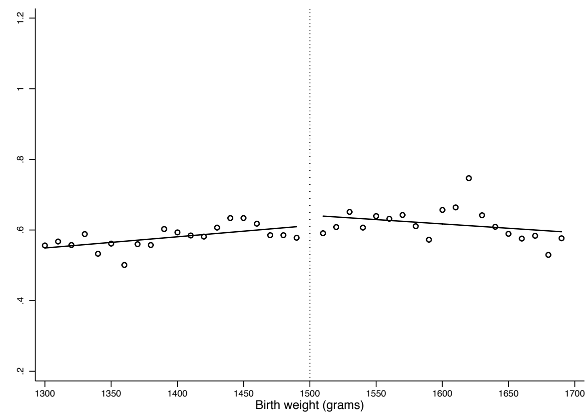
(a) Maternal age at birth of focal child



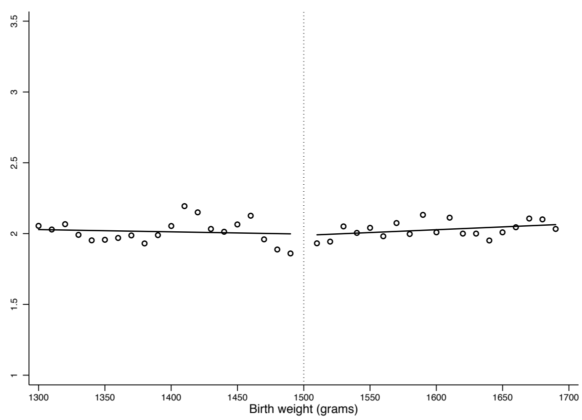
(b) Maternal years of education



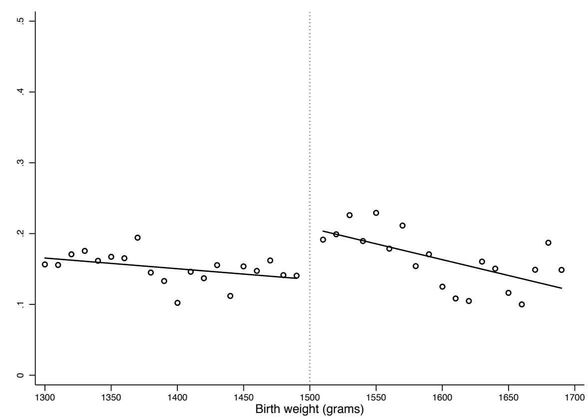
(c) Maternal immigrant status



(d) Focal child male



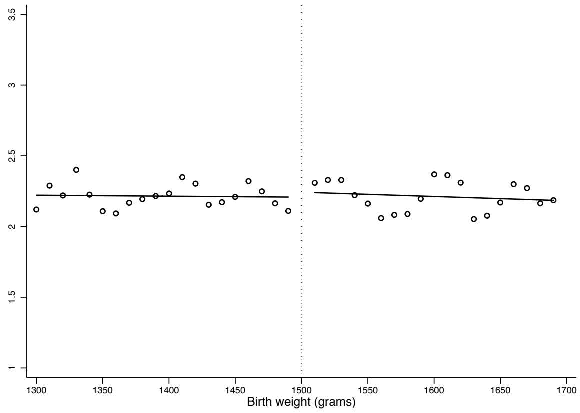
(e) Focal child parity



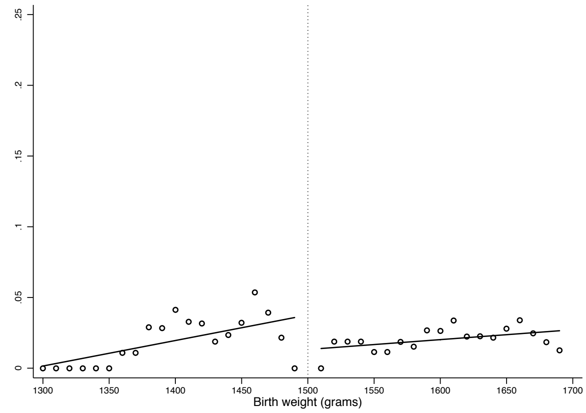
(f) Focal child plurality

Figure A3: Distribution of selected covariates around VLBW cutoff, focal children with siblings, gestational age < 32 weeks

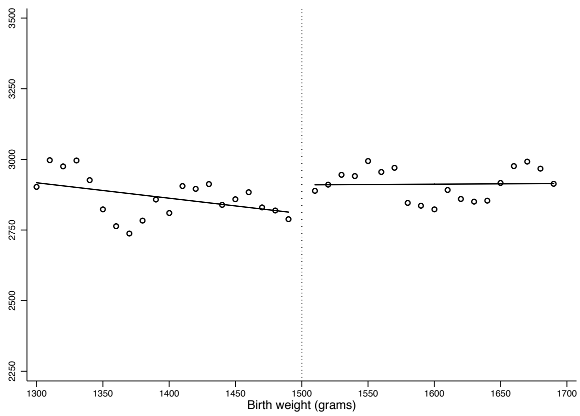
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



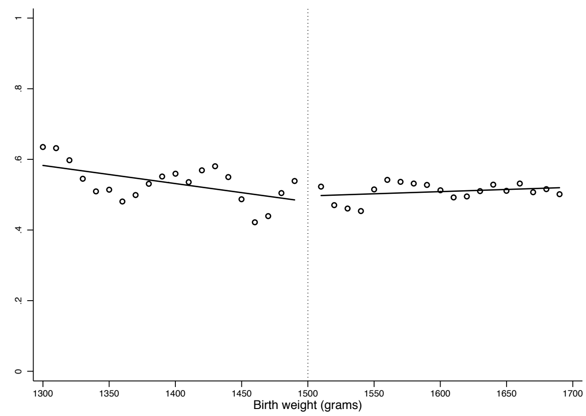
(a) Sibling parity



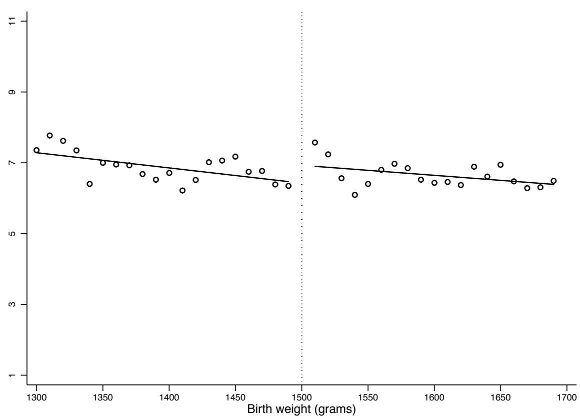
(b) Sibling plurality



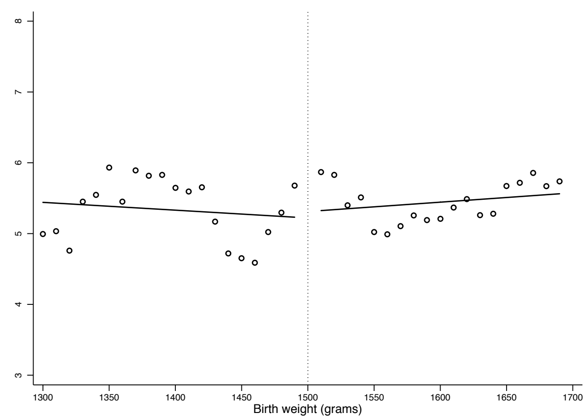
(c) Sibling birth weight



(d) Sibling male



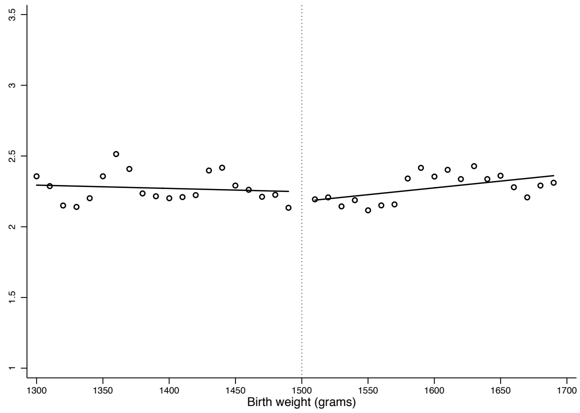
(e) Age difference, older siblings



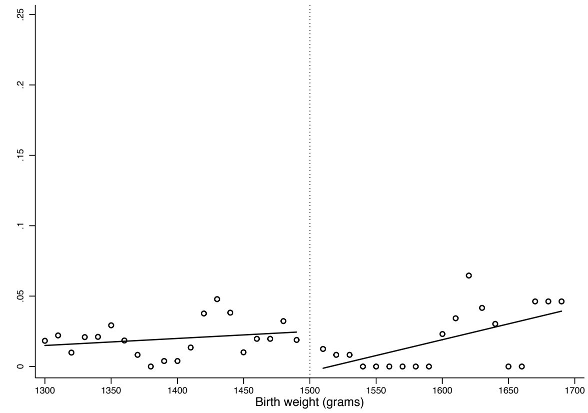
(f) Age difference, younger siblings

Figure A4: Distribution of selected covariates around VLBW cutoff, siblings of focal children with gestational age ≥ 32 weeks

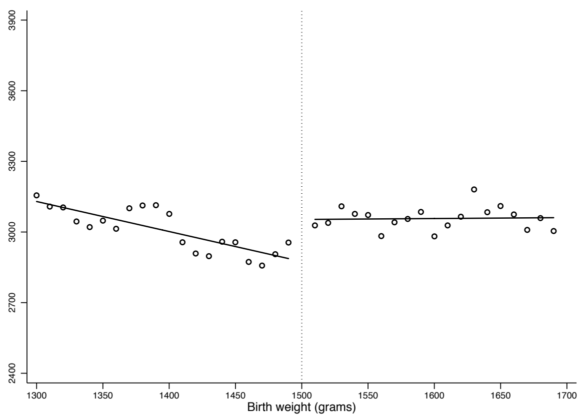
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



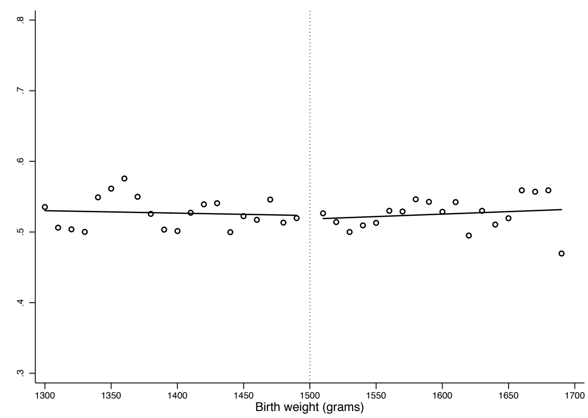
(a) Sibling parity



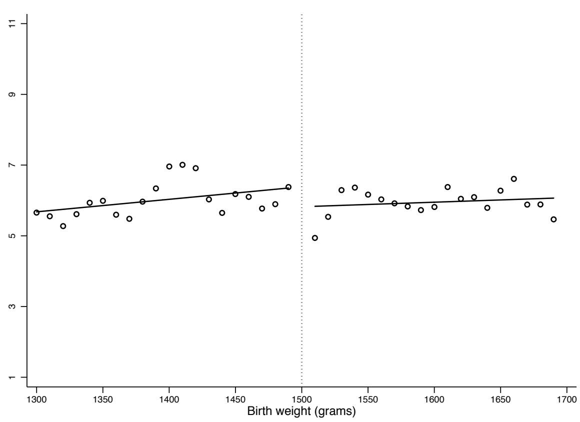
(b) Sibling plurality



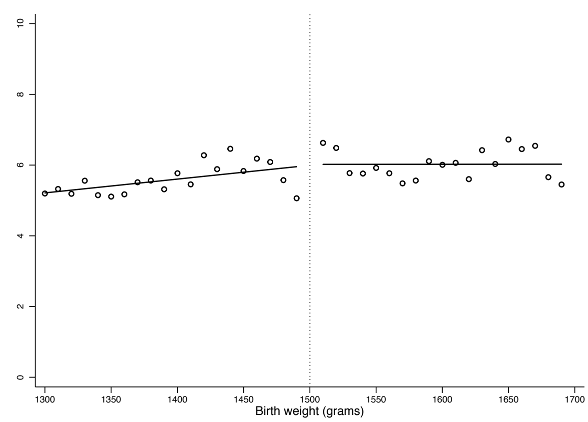
(c) Sibling birth weight



(d) Sibling male



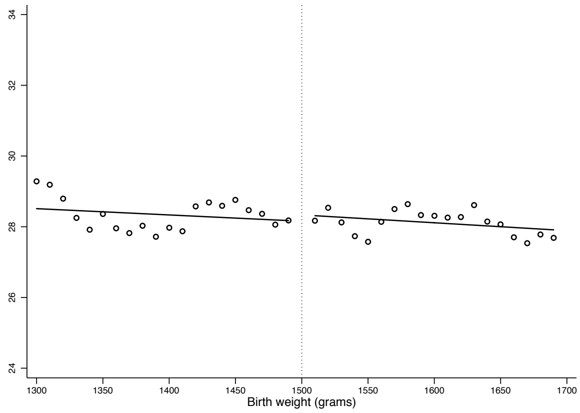
(e) Age difference, older siblings



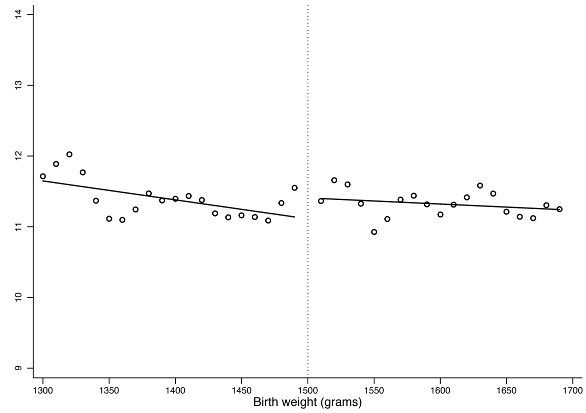
(f) Age difference, younger siblings

Figure A5: Distribution of selected covariates around VLBW cutoff, siblings of focal children with gestational age < 32 weeks

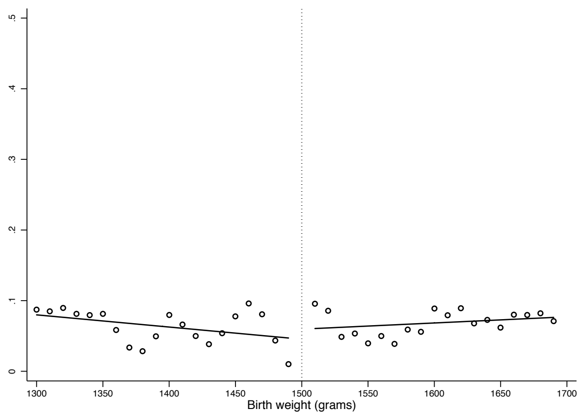
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



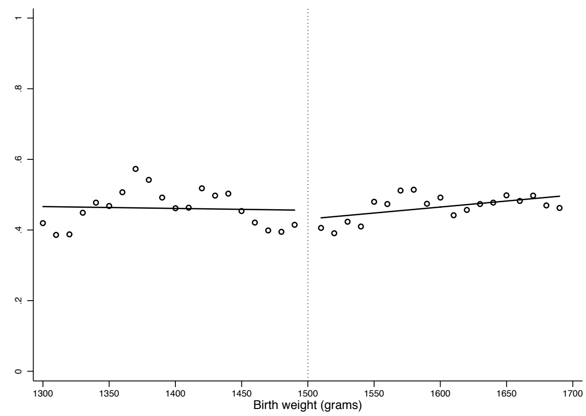
(a) Maternal age at birth of focal child



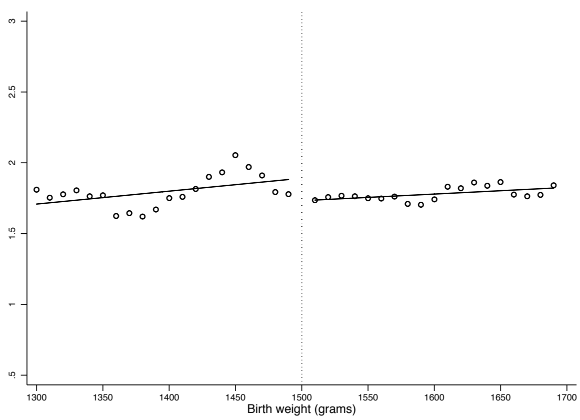
(b) Maternal years of education



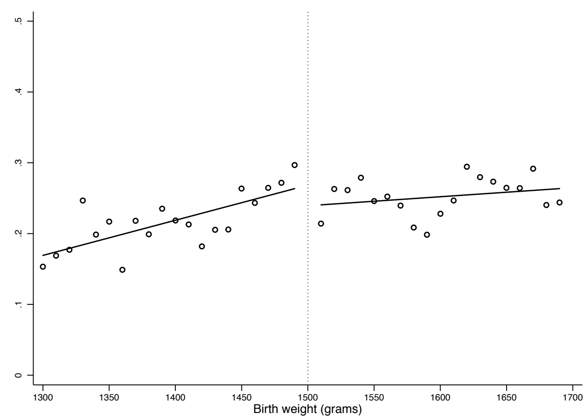
(c) Maternal immigrant status



(d) Focal child male



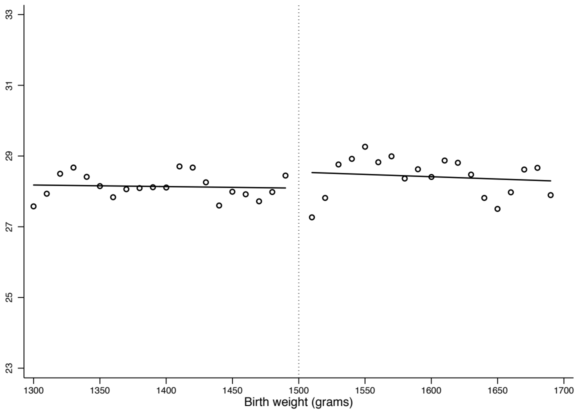
(e) Focal child parity



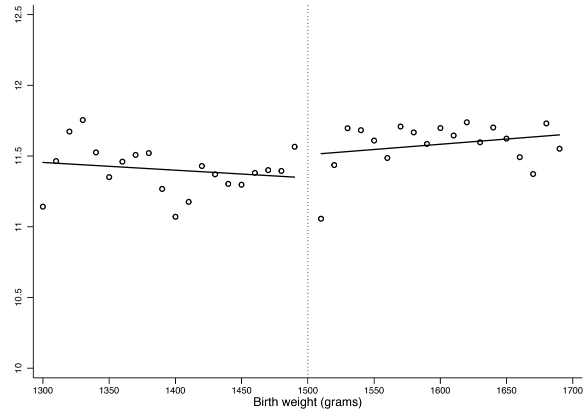
(f) Focal child plurality

Appendix Figure A6: Distribution of selected covariates around VLBW cutoff, all focal children, gestational age ≥ 32 weeks

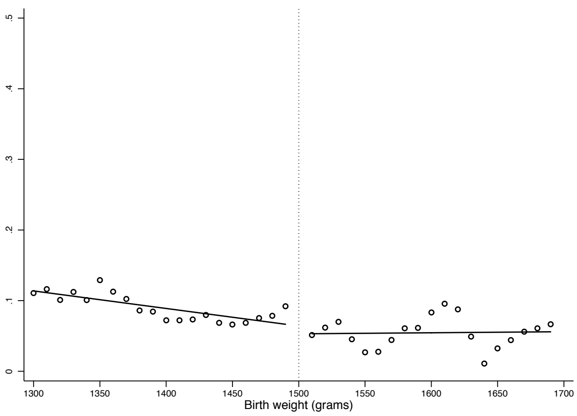
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



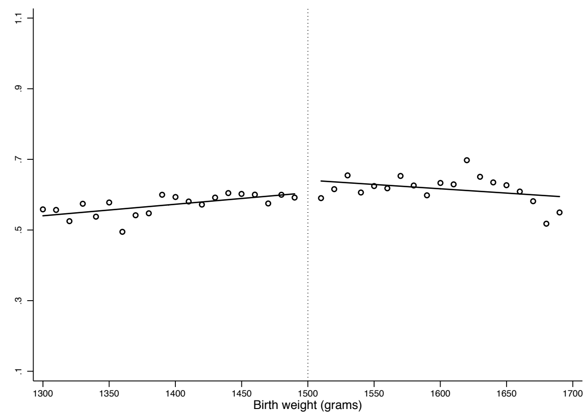
(a) Maternal age at birth of focal child



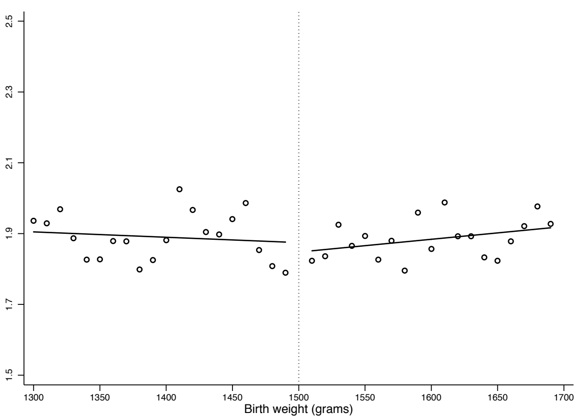
(b) Maternal years of education



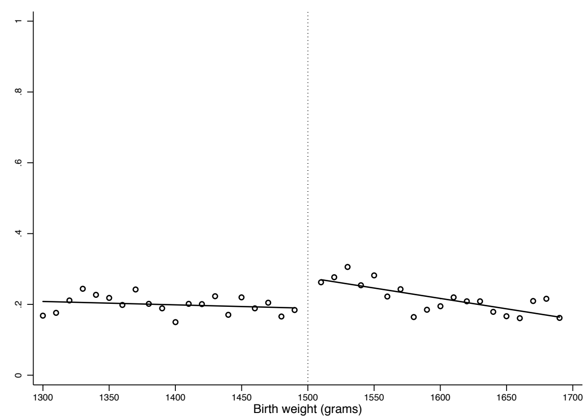
(c) Maternal immigrant status



(d) Focal child male



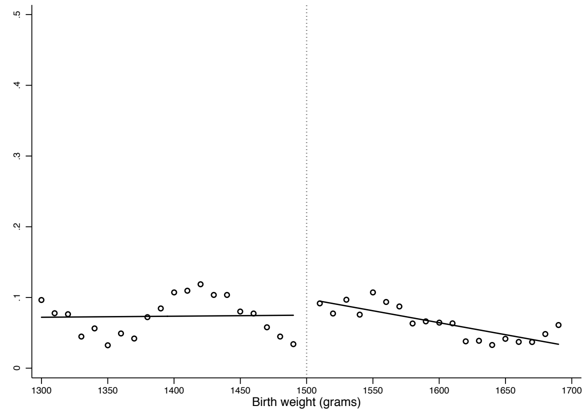
(e) Focal child parity



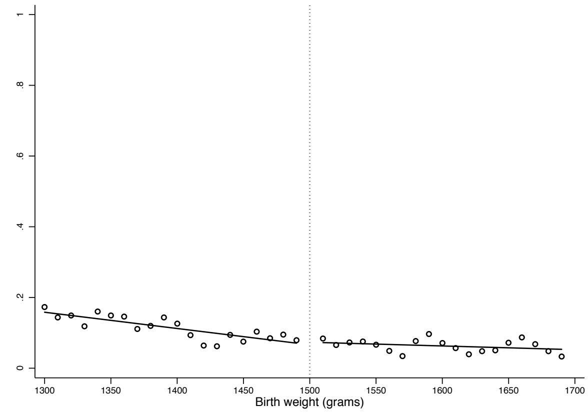
(f) Focal child plurality

Appendix Figure A7: Distribution of selected covariates around VLBW cutoff, all focal children, gestational age < 32 weeks

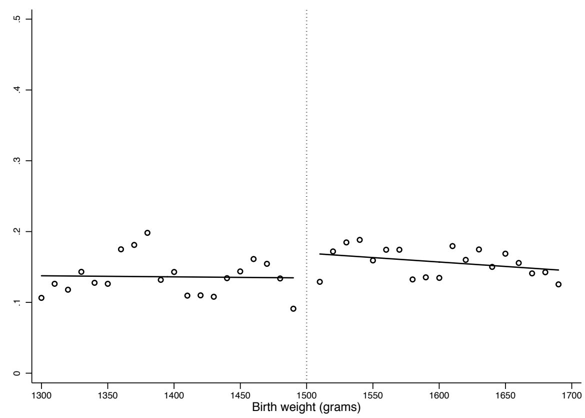
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



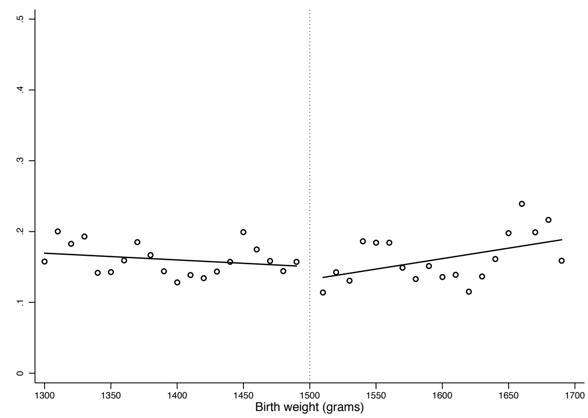
(a) 1-year mortality,
gestational age ≥ 32 weeks



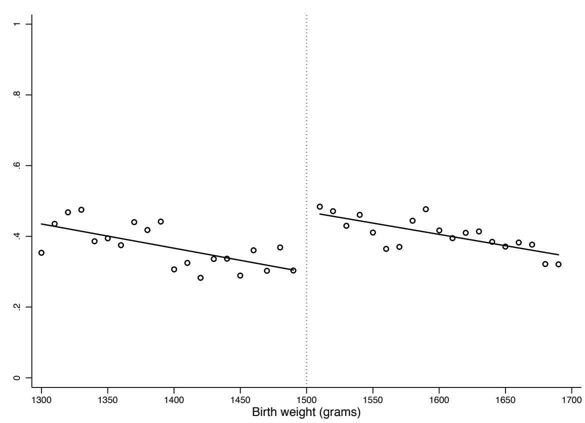
(b) 1-year mortality,
gestational age < 32 weeks



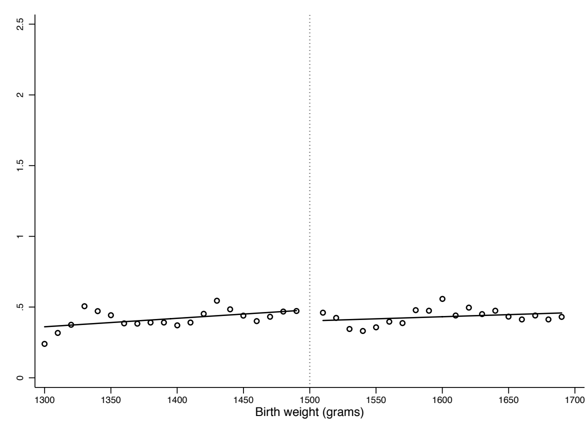
(c) Hospital admission, focal child age 6-10,
gestational age ≥ 32 weeks



(d) Hospital admission, focal child age 6-10,
gestational age < 32 weeks



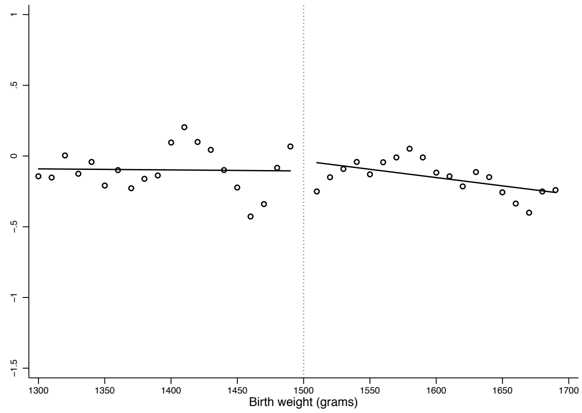
(e) ER admission, focal child age 6-10,
gestational age ≥ 32 weeks



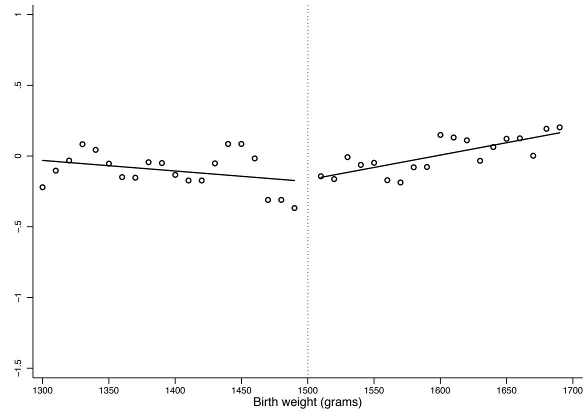
(f) ER admission, focal child age 6-10,
gestational age < 32 weeks

Appendix Figure A8: Distribution of health outcomes around VLBW cutoff, all focal children

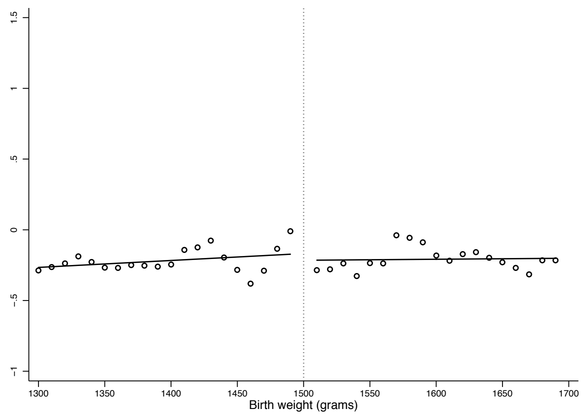
Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.



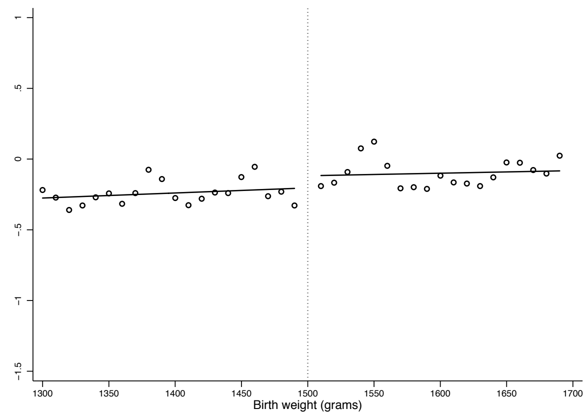
(a) Language test score,
gestational age ≥ 32 weeks



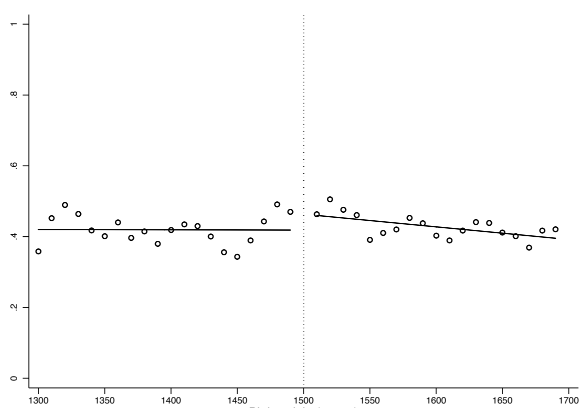
(b) Language test score,
gestational age < 32 weeks



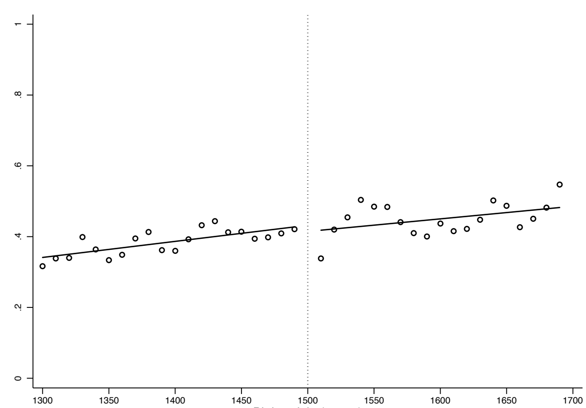
(c) Math test score,
gestational age ≥ 32 weeks



(d) Math test score,
gestational age < 32 weeks



(e) High school enrollment,
gestational age ≥ 32 weeks



(f) High school enrollment,
gestational age < 32 weeks

Appendix Figure A9: Distribution of academic achievement outcomes around VLBW cutoff, all focal children

Notes: Each dot represents the average of the variable indicated in the panel for a 30g bin centered at 10-gram intervals of birth weight. Children with birth weight of 1,500g are excluded. The lines plot a linear fit estimated separately on either side of the VLBW cutoff.

Appendix Table A1: Bandwidth choice

	All focal children	Focal children with siblings	Siblings
	(1)	(2)	(3)
A. Short-term health	220	190	
28-day mortality	180	190	
1-year mortality			
B. Long-term health			
Intellectual disability diagnosis by age 5	220	290	
Ever admitted to hospital, focal child age 0-5	230	230	300
Ever admitted to hospital, focal child age 6-10	300	190	240
Ever admitted to hospital, focal child age 11-15	220	220	200
ER admission, focal child age 6-10	140	300	190
ER admission, focal child age 11-15	290	300	240
C. Academic achievement			
Language test score	290	280	230
Math test score	280	240	260
High school enrollment	290	260	170

Notes: Each cell indicates the bandwidth that minimizes the mean squared error between the predictions of two models regressing the dependent variable indicated in the row on birth weight in the sample indicated in the column: a local linear model and a fourth-degree polynomial in birth weight.

Appendix Table A2: Comparison of the analysis sample to all focal children

	Children with birth weight 1,300-1,700g			Children born between 1982-1993		
	All Children	Analysis Sample	p-value	All Children	Analysis Sample	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
A. Maternal characteristics at birth of focal child						
Education (years)	11.351	11.263	0.116	11.825	11.263	0.000
Age	28.086	27.846	0.036	28.065	27.846	0.010
Immigrant	0.070	0.072	0.754	0.071	0.072	0.906
Employed	0.749	0.732	0.076	0.776	0.732	0.000
Income	136,114	128,890	0.001	143,281	128,890	0.000
Circulatory disease diagnosis before delivery	0.021	0.021	0.861	0.011	0.021	0.000
Respiratory disease diagnosis before delivery	0.058	0.062	0.404	0.052	0.062	0.010
Psychiatric diagnosis before delivery	0.025	0.025	0.904	0.017	0.025	0.001
B. Paternal characteristics at birth of focal child						
Absent	0.021	0.019	0.493	0.008	0.019	0.000
Age	31.068	30.733	0.014	30.962	30.733	0.023
Education (years)	11.703	11.689	0.802	12.074	11.689	0.000
Immigrant	0.076	0.077	0.860	0.079	0.077	0.656
Employed	0.879	0.875	0.637	0.897	0.875	0.000
Income	207,790	203,921	0.212	220,135	203,921	0.000
Circulatory disease diagnosis before delivery	0.017	0.017	0.855	0.015	0.017	0.394
Respiratory disease diagnosis before delivery	0.042	0.044	0.652	0.041	0.044	0.470
Psychiatric diagnosis before delivery	0.029	0.030	0.723	0.019	0.030	0.000
C. Family characteristics						
Total income	344,498	333,503	0.010	363,533	333,503	0.000
Married parents	0.519	0.527	0.523	0.592	0.527	0.000
D. Child characteristics						
Birth order	1.829	1.961	0.000	1.786	1.961	0.000
Multiple birth	0.222	0.181	0.000	0.024	0.181	0.000
Gender: Male	0.513	0.511	0.874	0.514	0.511	0.728
Gestational age	32.340	32.323	0.771	39.539	32.323	0.000
Apgar score	8.865	8.768	0.050	9.851	8.768	0.000
C. Predicted child outcomes						
28-day mortality	0.047	0.047	0.258	0.004	0.047	0.000
1-year mortality	0.055	0.055	0.144	0.007	0.055	0.000
Intellectual disability diagnosis by age 5	0.005	0.005	0.264	0.002	0.005	0.000
Ever admitted to hospital, focal child age 0-5	0.616	0.605	0.072	0.637	0.605	0.000
Ever admitted to hospital, focal child age 6-10	0.135	0.134	0.396	0.111	0.134	0.000
Ever admitted to hospital, focal child age 11-15	0.115	0.114	0.508	0.108	0.114	0.000
ER admission, focal child age 6-10	0.344	0.340	0.117	0.343	0.340	0.184
ER admission, focal child age 11-15	0.331	0.326	0.131	0.344	0.326	0.000
Language test score	-0.071	-0.101	0.000	-0.012	-0.101	0.000
Math test score	-0.129	-0.165	0.000	-0.003	-0.165	0.000
High school enrollment	0.471	0.451	0.000	0.581	0.451	0.000
Observations	4,599	3,677		699,613		

Notes: Each cell in Columns 1-2 and 4-5 represents the mean of the corresponding variable in the row. Columns 3 and 6 present the *p*-value for differences in means.

Appendix Table A3: Estimating samples across outcomes

Sample/outcome	Cohorts	Reason for restriction
A. Focal children	1982-1993	Gestational age not recorded until 1982; test scores available until 2010
- Mortality	1982-1993	Ibid.
- Diagnoses	1982-1993	Ibid.
- Hospitalizations	1982-1993	Ibid.
- ER visits, 6-10 years	1989-1993	ER data available from 1995
- ER visits, 11-15 years	1984-1993	ER data available from 1995
- Test scores	1986-1993	Test scores available between 2001-2010
- High school enrollment	1982-1993	Gestational age not recorded until 1982; test scores available until 2010
B. Siblings	1970-2010	Siblings of focal children born between 1982-1993
- ER visits, 6-10 years after birth of focal child	1970-2010	Siblings of focal children born between 1989-1993; ER data available from 1995
- ER visits, 11-15 years after birth of focal child	1970-2010	Siblings of focal children born between 1984-1993; ER data available from 1995
- Test scores	1986-1997	Siblings of focal children born between 1982-1993; test scores available between 2001-2010
- High school enrollment	1973-1993	Siblings of focal children born between 1982-1993

Appendix Table A4: Distribution of covariates across the VLBW cutoff, all focal children

	Gestational age ≥ 32 weeks			Gestational age < 32 weeks		
	Birth weight < 1,500g	Birth weight ≥ 1,500g	p-value	Birth weight < 1,500g	Birth weight ≥ 1,500g	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
A. Parental characteristics						
Mother's education (years)	11.262	11.432	0.502	11.377	11.325	0.821
Mother's age at birth of focal child	28.439	28.196	0.618	28.168	28.160	0.987
Immigrant mother	0.049	0.056	0.810	0.067	0.062	0.805
Married parents	0.522	0.510	0.848	0.461	0.503	0.473
B. Child characteristics						
Birth order	1.933	1.694	0.040	1.905	1.815	0.367
Multiple birth	0.280	0.237	0.242	0.187	0.255	0.089
Gender: Male	0.417	0.429	0.830	0.617	0.612	0.903
Gestational age	33.707	33.990	0.059	30.200	30.169	0.717
C. Predicted outcomes						
Mortality, 28-days	0.038	0.037	0.083	0.060	0.060	0.669
Mortality, 1-year	0.045	0.043	0.066	0.069	0.069	0.609
Intellectual disability diagnosis by age 5	0.0047	0.0045	0.248	0.0065	0.0064	0.497
Hospital admission, focal child age 0-5	0.643	0.629	0.746	0.630	0.652	0.660
Hospital admission, focal child age 6-10	0.132	0.129	0.667	0.147	0.149	0.801
Hospital admission, focal child age 11-15	0.118	0.115	0.612	0.120	0.123	0.765
ER admission, focal child age 6-10	0.354	0.349	0.744	0.357	0.358	0.952
ER admission, focal child age 11-15	0.347	0.339	0.715	0.341	0.348	0.775
Language test score	-0.035	-0.005	0.411	-0.127	-0.114	0.680
Math test score	-0.126	-0.087	0.269	-0.162	-0.135	0.425
High school enrollment	0.507	0.524	0.407	0.418	0.430	0.559
Observations	874	1,834		1,045	846	

Notes: Sample of focal children with birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell in Columns 1-2 and 4-5 represents the mean of the corresponding variable in the row after controlling for birth weight. Columns 3 and 6 present the *p*-value for differences in means clustered at the gram level.

Appendix Table A5: Baseline regressions, all focal children

	Gestational age	
	≥ 32 weeks	< 32 weeks
	(1)	(2)
A. Short-term health		
28-day mortality	-0.033*	-0.011
	(0.019)	(0.026)
Mean outcome, non-VLBW focal children	0.051	0.058
Observations	2,708	1,891
1-year mortality	-0.034	-0.001
	(0.022)	(0.030)
Mean outcome, non-VLBW focal children	0.067	0.069
Observations	2,708	1,891
B. Long-term health		
Intellectual disability diagnosis by age 5	-0.012	0.016
	(0.008)	(0.011)
Mean outcome, non-VLBW focal children	0.011	0.002
Observations	2,708	1,891
Ever admitted to hospital, focal child age 0-5	0.019	0.030
	(0.050)	(0.073)
Mean outcome, non-VLBW focal children	0.579	0.617
Observations	2,708	1,891
Ever admitted to hospital, focal child age 6-10	-0.051	0.001
	(0.035)	(0.039)
Mean outcome, non-VLBW focal children	0.153	0.166
Observations	2,498	1,694
Ever admitted to hospital, focal child age 11-15	-0.041	-0.026
	(0.031)	(0.028)
Mean outcome, non-VLBW focal children	0.118	0.127
Observations	2,497	1,691
ER admission, focal child age 6-10	-0.131**	0.070
	(0.061)	(0.059)
Mean outcome, non-VLBW focal children	0.401	0.416
Observations	1,033	809
ER admission, age 11-15	-0.065	-0.016
	(0.052)	(0.056)
Mean outcome, non-VLBW focal children	0.328	0.326
Observations	2,080	1,445

Appendix Table A5: Baseline regressions, all focal children (cont'd)

	Gestational age	
	≥ 32 weeks	< 32 weeks
	(1)	(2)
C. Academic achievement		
Language test score	0.007	-0.138
	(0.151)	(0.125)
Mean outcome, non-VLBW focal children	-0.158	0.003
Observations	1,243	911
Math test score	0.168*	-0.211
	(0.100)	(0.160)
Mean outcome, non-VLBW focal children	-0.242	-0.075
Observations	1,226	917
High school enrollment	-0.030	0.023
	(0.047)	(0.050)
Mean outcome, non-VLBW focal children	0.417	0.442
Observations	2,708	1,891

Notes: Sample of all focal children with birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A6: Robustness to choice of bandwidth and degree of polynomial in birth weight, siblings of focal children with gestational age of at least 32 weeks

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 100 grams			Bandwidth = 110 grams			Bandwidth = 120 grams			Bandwidth = 130 grams		
Language test score	0.499***	0.628***	0.524	0.484***	0.571***	0.598**	0.473***	0.537***	0.527**	0.464***	0.520***	0.507**
	(0.146)	(0.214)	(0.339)	(0.129)	(0.194)	(0.296)	(0.121)	(0.188)	(0.253)	(0.115)	(0.183)	(0.221)
Observations	754	754	754	816	816	816	878	878	878	948	948	948
Math test score	0.442*	0.032	-0.458	0.417*	0.272	-0.372	0.404*	0.359	-0.108	0.392*	0.424	0.136
	(0.249)	(0.318)	(0.346)	(0.226)	(0.319)	(0.261)	(0.215)	(0.308)	(0.269)	(0.205)	(0.298)	(0.286)
Observations	758	758	758	819	819	819	882	882	882	954	954	954
High school enrollment	0.161**	0.233**	0.224	0.140**	0.194**	0.122	0.127**	0.171*	0.066	0.121**	0.149*	0.083
	(0.067)	(0.099)	(0.142)	(0.059)	(0.093)	(0.141)	(0.056)	(0.088)	(0.122)	(0.054)	(0.085)	(0.103)
Observations	1,363	1,363	1,363	1,458	1,458	1,458	1,568	1,568	1,568	1,688	1,688	1,688
	Bandwidth = 140 grams			Bandwidth = 150 grams			Bandwidth = 160 grams			Bandwidth = 170 grams		
Language test score	0.455***	0.514***	0.507**	0.439***	0.532***	0.483**	0.413***	0.558***	0.471**	0.395***	0.559***	0.489**
	(0.110)	(0.177)	(0.212)	(0.106)	(0.172)	(0.208)	(0.103)	(0.165)	(0.206)	(0.100)	(0.158)	(0.206)
Observations	999	999	999	1,116	1,116	1,116	1,172	1,172	1,172	1,230	1,230	1,230
Math test score	0.385*	0.441	0.263	0.376**	0.461	0.318	0.363**	0.472*	0.358	0.348**	0.478*	0.379
	(0.195)	(0.289)	(0.314)	(0.186)	(0.282)	(0.321)	(0.177)	(0.273)	(0.321)	(0.168)	(0.266)	(0.318)
Observations	1,005	1,005	1,005	1,120	1,120	1,120	1,176	1,176	1,176	1,234	1,234	1,234
High school enrollment	0.117**	0.138*	0.103	0.113**	0.137*	0.109	0.110**	0.132*	0.122	0.105**	0.132*	0.122
	(0.052)	(0.081)	(0.097)	(0.051)	(0.078)	(0.095)	(0.049)	(0.073)	(0.094)	(0.047)	(0.070)	(0.094)
Observations	1,777	1,777	1,777	1,989	1,989	1,989	2,103	2,103	2,103	2,183	2,183	2,183

Appendix Table A6: Robustness to choice of bandwidth and degree of polynomial in birth weight, siblings of focal children with gestational age of at least 32 weeks (cont'd)

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 180 grams			Bandwidth = 190 grams			Bandwidth = 200 grams			Bandwidth = 210 grams		
Language test score	0.380***	0.554***	0.511**	0.367***	0.545***	0.533***	**0.358***	0.529***	0.558***	0.339***	0.516***	0.556***
	(0.097)	(0.154)	(0.205)	(0.095)	(0.148)	(0.202)	**(0.093)**	(0.143)	(0.199)	(0.091)	(0.133)	(0.194)
Observations	1,304	1,304	1,304	1,345	1,345	1,345	**1,511**	1,511	1,511	1,562	1,562	1,562
Math test score	0.336**	0.476*	0.409	0.324**	0.475*	0.428	**0.313**	0.470*	0.452	0.300**	0.461*	0.474
	(0.162)	(0.260)	(0.314)	(0.156)	(0.254)	(0.310)	**(0.151)**	(0.247)	(0.305)	(0.144)	(0.235)	(0.300)
Observations	1,308	1,308	1,308	1,349	1,349	1,349	**1,517**	1,517	1,517	1,567	1,567	1,567
High school enrollment	0.103**	0.129*	0.126	0.100**	0.129*	0.124	**0.095**	0.131**	0.119	0.088**	0.135**	0.115
	(0.045)	(0.068)	(0.093)	(0.044)	(0.066)	(0.091)	**(0.043)**	(0.064)	(0.089)	(0.042)	(0.061)	(0.085)
Observations	2,301	2,301	2,301	2,375	2,375	2,375	**2,658**	2,658	2,658	2,750	2,750	2,750
	Bandwidth = 220 grams			Bandwidth = 230 grams			Bandwidth = 240 grams			Bandwidth = 250 grams		
Language test score	0.324***	0.505***	0.558***	0.311***	0.495***	0.554***	0.297***	0.487***	0.546***	0.284***	0.480***	0.536***
	(0.089)	(0.128)	(0.192)	(0.088)	(0.125)	(0.189)	(0.087)	(0.122)	(0.183)	(0.086)	(0.119)	(0.177)
Observations	1,627	1,627	1,627	1,706	1,706	1,706	1,767	1,767	1,767	1,884	1,884	1,884
Math test score	0.291**	0.452**	0.486	0.284**	0.441**	0.494*	0.278**	0.429**	0.501*	0.271**	0.418**	0.503*
	(0.139)	(0.227)	(0.297)	(0.135)	(0.221)	(0.294)	(0.131)	(0.215)	(0.288)	(0.127)	(0.209)	(0.282)
Observations	1,631	1,631	1,631	1,707	1,707	1,707	1,768	1,768	1,768	1,887	1,887	1,887
High school enrollment	0.083**	0.136**	0.116	0.078*	0.138**	0.116	0.073*	0.139**	0.120	0.069*	0.137**	0.125
	(0.041)	(0.059)	(0.084)	(0.040)	(0.058)	(0.081)	(0.040)	(0.056)	(0.079)	(0.039)	(0.054)	(0.076)
Observations	2,868	2,868	2,868	3,009	3,009	3,009	3,138	3,138	3,138	3,383	3,383	3,383

Appendix Table A6: Robustness to choice of bandwidth and degree of polynomial in birth weight, siblings of focal children with gestational age of at least 32 weeks (cont'd)

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 260 grams			Bandwidth = 270 grams			Bandwidth = 280 grams			Bandwidth = 290 grams		
Language test score	0.270***	0.471***	0.527***	0.261***	0.459***	0.530***	0.255***	0.444***	0.538***	0.249***	0.432***	0.537***
	(0.086)	(0.117)	(0.172)	(0.085)	(0.115)	(0.168)	(0.084)	(0.114)	(0.163)	(0.083)	(0.113)	(0.159)
Observations	1,955	1,955	1,955	2,021	2,021	2,021	2,101	2,101	2,101	2,179	2,179	2,179
Math test score	0.262**	0.413**	0.493*	0.254**	0.409**	0.485*	0.246**	0.405**	0.480*	0.237**	0.404**	0.467*
	(0.124)	(0.204)	(0.277)	(0.121)	(0.199)	(0.272)	(0.118)	(0.195)	(0.267)	(0.116)	(0.191)	(0.262)
Observations	1,962	1,962	1,962	2,026	2,026	2,026	2,107	2,107	2,107	2,182	2,182	2,182
High school enrollment	0.065*	0.133**	0.130*	0.062	0.131**	0.133*	0.059	0.128**	0.137*	0.057	0.125**	0.139**
	(0.039)	(0.053)	(0.074)	(0.039)	(0.052)	(0.073)	(0.038)	(0.051)	(0.071)	(0.038)	(0.050)	(0.070)
Observations	3,494	3,494	3,494	3,601	3,601	3,601	3,749	3,749	3,749	3,882	3,882	3,882
	Bandwidth = 300 grams											
Language test score	0.242***	0.425***	0.527***									
	(0.083)	(0.112)	(0.155)									
Observations	2,416	2,416	2,416									
Math test score	0.225**	0.409**	0.447*									
	(0.114)	(0.186)	(0.257)									
Observations	2,419	2,419	2,419									
High school enrollment	0.054	0.124**	0.136**									
	(0.038)	(0.049)	(0.068)									
Observations	4,291	4,291	4,291									

Notes: Sample of siblings of focal children with gestational age of at least 32 weeks and birth weight within a bandwidth around the 1,500g cutoff indicated in panel headings. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A7: Robustness to choice of bandwidth and degree of polynomial in birth weight, focal children with siblings and with gestational age of at least 32 weeks

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 100 grams			Bandwidth = 110 grams			Bandwidth = 120 grams			Bandwidth = 130 grams		
28-day mortality	-0.061	-0.046	-0.040	-0.074**	-0.075	-0.081	-0.075**	-0.091**	-0.104**	-0.071**	-0.104***	-0.115***
	(0.041)	(0.056)	(0.063)	(0.033)	(0.046)	(0.057)	(0.030)	(0.040)	(0.043)	(0.029)	(0.036)	(0.035)
Observations	1,085	1,085	1,085	1,169	1,169	1,169	1,259	1,259	1,259	1,362	1,362	1,362
1-year mortality	-0.082*	-0.064	-0.030	-0.087**	-0.085	-0.056	-0.085**	-0.097**	-0.082*	-0.080**	-0.110**	-0.096**
	(0.047)	(0.071)	(0.083)	(0.036)	(0.055)	(0.065)	(0.033)	(0.047)	(0.049)	(0.031)	(0.042)	(0.039)
Observations	1,085	1,085	1,085	1,169	1,169	1,169	1,259	1,259	1,259	1,362	1,362	1,362
Math test score	0.686***	0.887***	1.287***	0.595***	0.759***	0.975**	0.550***	0.747***	0.940***	0.520***	0.743***	0.894***
	(0.162)	(0.285)	(0.420)	(0.162)	(0.254)	(0.378)	(0.161)	(0.216)	(0.302)	(0.156)	(0.189)	(0.255)
Observations	466	466	466	502	502	502	540	540	540	598	598	598
	Bandwidth = 140 grams			Bandwidth = 150 grams			Bandwidth = 160 grams			Bandwidth = 170 grams		
28-day mortality	-0.068**	-0.107***	-0.117***	-0.064**	-0.109***	-0.117***	-0.059**	-0.107***	-0.121***	-0.055**	-0.105***	-0.122***
	(0.028)	(0.034)	(0.031)	(0.027)	(0.032)	(0.031)	(0.026)	(0.031)	(0.031)	(0.025)	(0.030)	(0.031)
Observations	1,445	1,445	1,445	1,603	1,603	1,603	1,693	1,693	1,693	1,773	1,773	1,773
1-year mortality	-0.076**	-0.111***	-0.106***	-0.071**	-0.114***	-0.109***	-0.066**	-0.113***	-0.114***	-0.060**	-0.112***	-0.116***
	(0.030)	(0.039)	(0.037)	(0.029)	(0.036)	(0.036)	(0.028)	(0.035)	(0.037)	(0.028)	(0.034)	(0.037)
Observations	1,445	1,445	1,445	1,603	1,603	1,603	1,693	1,693	1,693	1,773	1,773	1,773
Math test score	0.495***	0.730***	0.857***	0.474***	0.709***	0.834***	0.458***	0.678***	0.821***	0.438***	0.663***	0.792***
	(0.152)	(0.177)	(0.236)	(0.149)	(0.172)	(0.224)	(0.146)	(0.170)	(0.214)	(0.144)	(0.168)	(0.208)
Observations	635	635	635	702	702	702	741	741	741	778	778	778

Appendix Table A7: Robustness to choice of bandwidth and degree of polynomial in birth weight, focal children with siblings and with gestational age of at least 32 weeks (cont'd)

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 180 grams			Bandwidth = 190 grams			Bandwidth = 200 grams			Bandwidth = 210 grams		
28-day mortality	-0.052**	-0.103***	-0.124***	-0.048**	-0.100***	-0.125***	**-0.047****	-0.096***	-0.128***	-0.045**	-0.091***	-0.130***
	(0.025)	(0.030)	(0.031)	(0.024)	(0.029)	(0.031)	**(0.023)**	(0.029)	(0.031)	(0.022)	(0.029)	(0.030)
Observations	1,874	1,874	1,874	1,941	1,941	1,941	**2,156**	2,156	2,156	2,239	2,239	2,239
1-year mortality	-0.056**	-0.111***	-0.119***	-0.052*	-0.109***	-0.121***	**-0.048***	-0.105***	-0.124***	-0.043*	-0.100***	-0.126***
	(0.027)	(0.033)	(0.037)	(0.027)	(0.032)	(0.037)	**(0.026)**	(0.032)	(0.036)	(0.025)	(0.031)	(0.036)
Observations	1,874	1,874	1,874	1,941	1,941	1,941	**2,156**	2,156	2,156	2,239	2,239	2,239
Math test score	0.420***	0.651***	0.780***	0.398***	0.646***	0.757***	**0.382*****	0.632***	0.753***	0.365**	0.606***	0.755***
	(0.143)	(0.166)	(0.201)	(0.143)	(0.164)	(0.195)	**(0.143)**	(0.163)	(0.189)	(0.141)	(0.160)	(0.182)
Observations	824	824	824	852	852	852	**926**	926	926	969	969	969
	Bandwidth = 220 grams			Bandwidth = 230 grams			Bandwidth = 240 grams			Bandwidth = 250 grams		
28-day mortality	-0.044**	-0.087***	-0.130***	-0.043**	-0.085***	-0.129***	-0.042**	-0.081***	-0.128***	-0.041**	-0.078***	-0.126***
	(0.022)	(0.028)	(0.030)	(0.021)	(0.028)	(0.030)	(0.021)	(0.028)	(0.029)	(0.020)	(0.028)	(0.029)
Observations	2,337	2,337	2,337	2,440	2,440	2,440	2,537	2,537	2,537	2,730	2,730	2,730
1-year mortality	-0.039	-0.096***	-0.126***	-0.036	-0.092***	-0.126***	-0.034	-0.087***	-0.126***	-0.032	-0.083***	-0.126***
	(0.024)	(0.030)	(0.035)	(0.024)	(0.030)	(0.034)	(0.023)	(0.030)	(0.034)	(0.023)	(0.029)	(0.033)
Observations	2,337	2,337	2,337	2,440	2,440	2,440	2,537	2,537	2,537	2,730	2,730	2,730
Math test score	0.351**	0.583***	0.749***	0.339**	0.561***	0.738***	0.328**	0.539***	0.722***	0.318**	0.520***	0.708***
	(0.140)	(0.158)	(0.179)	(0.138)	(0.156)	(0.177)	(0.136)	(0.154)	(0.174)	(0.134)	(0.153)	(0.171)
Observations	1,018	1,018	1,018	1,075	1,075	1,075	1,127	1,127	1,127	1,220	1,220	1,220

Appendix Table A7: Robustness to choice of bandwidth and degree of polynomial in birth weight, focal children with siblings and with gestational age of at least 32 weeks (cont'd)

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 260 grams			Bandwidth = 270 grams			Bandwidth = 280 grams			Bandwidth = 290 grams		
28-day mortality	-0.040**	-0.076***	-0.123***	-0.039**	-0.074***	-0.120***	-0.038**	-0.072***	-0.118***	-0.037**	-0.071***	-0.114***
	(0.020)	(0.028)	(0.029)	(0.019)	(0.027)	(0.029)	(0.019)	(0.027)	(0.029)	(0.019)	(0.027)	(0.029)
Observations	2,830	2,830	2,830	2,924	2,924	2,924	3,042	3,042	3,042	3,147	3,147	3,147
1-year mortality	-0.030	-0.078***	-0.124***	-0.028	-0.075**	-0.122***	-0.026	-0.072**	-0.119***	-0.024	-0.069**	-0.117***
	(0.022)	(0.029)	(0.032)	(0.021)	(0.029)	(0.032)	(0.021)	(0.029)	(0.031)	(0.021)	(0.029)	(0.031)
Observations	2,830	2,830	2,830	2,924	2,924	2,924	3,042	3,042	3,042	3,147	3,147	3,147
Math test score	0.304**	0.510***	0.683***	0.290**	0.502***	0.663***	0.279**	0.493***	0.654***	0.273**	0.477***	0.654***
	(0.132)	(0.152)	(0.168)	(0.131)	(0.152)	(0.167)	(0.129)	(0.152)	(0.165)	(0.128)	(0.152)	(0.163)
Observations	1,272	1,272	1,272	1,309	1,309	1,309	1,353	1,353	1,353	1,399	1,399	1,399
	Bandwidth = 300 grams											
28-day mortality	-0.036**	-0.069**	-0.112***									
	(0.018)	(0.027)	(0.028)									
Observations	3,467	3,467	3,467									
1-year mortality	-0.023	-0.065**	-0.117***									
	(0.020)	(0.029)	(0.031)									
Observations	3,467	3,467	3,467									
Math test score	0.266**	0.466***	0.645***									
	(0.126)	(0.153)	(0.162)									
Observations	1,529	1,529	1,529									

Notes: Sample of focal children with siblings and with gestational age of at least 32 weeks and birth weight within a bandwidth around the 1,500g cutoff indicated in panel headings. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A8: Robustness to choice of bandwidth and degree of polynomial in birth weight, all focal children with gestational age of at least 32 weeks

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 100 grams			Bandwidth = 110 grams			Bandwidth = 120 grams			Bandwidth = 130 grams		
28-day mortality	-0.049	-0.036	-0.022	-0.058**	-0.062*	-0.054	-0.058**	-0.073**	-0.072**	-0.054**	-0.083***	-0.084***
	(0.031)	(0.040)	(0.042)	(0.025)	(0.035)	(0.041)	(0.023)	(0.031)	(0.031)	(0.022)	(0.028)	(0.026)
Observations	1,352	1,352	1,352	1,450	1,450	1,450	1,568	1,568	1,568	1,698	1,698	1,698
1-year mortality	-0.066*	-0.043	-0.006	-0.070**	-0.070	-0.030	-0.069**	-0.082**	-0.054	-0.064**	-0.092***	-0.069**
	(0.036)	(0.050)	(0.054)	(0.029)	(0.043)	(0.047)	(0.027)	(0.038)	(0.037)	(0.025)	(0.034)	(0.032)
Observations	1,352	1,352	1,352	1,450	1,450	1,450	1,568	1,568	1,568	1,698	1,698	1,698
Math test score	0.310**	0.507**	0.798**	0.265**	0.395*	0.646**	0.240**	0.378**	0.634**	0.227**	0.366**	0.609***
	(0.119)	(0.235)	(0.336)	(0.115)	(0.205)	(0.302)	(0.113)	(0.174)	(0.245)	(0.111)	(0.150)	(0.208)
Observations	615	615	615	658	658	658	716	716	716	790	790	790
	Bandwidth = 140 grams			Bandwidth = 150 grams			Bandwidth = 160 grams			Bandwidth = 170 grams		
28-day mortality	-0.051**	-0.085***	-0.088***	-0.047**	-0.086***	-0.090***	-0.043**	-0.085***	-0.095***	-0.039*	-0.083***	-0.097***
	(0.022)	(0.026)	(0.024)	(0.021)	(0.025)	(0.024)	(0.021)	(0.024)	(0.025)	(0.021)	(0.024)	(0.025)
Observations	1,806	1,806	1,806	2,000	2,000	2,000	2,112	2,112	2,112	2,219	2,219	2,219
1-year mortality	-0.060**	-0.093***	-0.082**	-0.055**	-0.095***	-0.086***	-0.050**	-0.095***	-0.093***	-0.045*	-0.094***	-0.096***
	(0.025)	(0.032)	(0.032)	(0.024)	(0.031)	(0.032)	(0.024)	(0.029)	(0.032)	(0.023)	(0.028)	(0.032)
Observations	1,806	1,806	1,806	2,000	2,000	2,000	2,112	2,112	2,112	2,219	2,219	2,219
Math test score	0.217**	0.351**	0.563***	0.209*	0.336**	0.519***	0.202*	0.319**	0.480***	0.194*	0.308**	0.447***
	(0.108)	(0.138)	(0.193)	(0.106)	(0.132)	(0.181)	(0.103)	(0.128)	(0.172)	(0.102)	(0.125)	(0.166)
Observations	838	838	838	920	920	920	974	974	974	1,027	1,027	1,027

Appendix Table A8: Robustness to choice of bandwidth and degree of polynomial in birth weight, all focal children with gestational age of at least 32 weeks (cont'd)

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 180 grams			Bandwidth = 190 grams			Bandwidth = 200 grams			Bandwidth = 210 grams		
28-day mortality	-0.037*	-0.080***	-0.099***	-0.034*	-0.078***	-0.100***	**-0.033***	-0.074***	-0.103***	-0.032*	-0.069***	-0.104***
	(0.020)	(0.023)	(0.025)	(0.020)	(0.023)	(0.025)	**(0.019)**	(0.023)	(0.025)	(0.018)	(0.023)	(0.024)
Observations	2,358	2,358	2,358	2,439	2,439	2,439	**2,708**	2,708	2,708	2,820	2,820	2,820
1-year mortality	-0.041*	-0.092***	-0.100***	-0.037	-0.090***	-0.102***	**-0.034**	-0.087***	-0.106***	-0.031	-0.081***	-0.108***
	(0.023)	(0.028)	(0.032)	(0.023)	(0.027)	(0.032)	**(0.022)**	(0.027)	(0.032)	(0.021)	(0.026)	(0.031)
Observations	2,358	2,358	2,358	2,439	2,439	2,439	**2,708**	2,708	2,708	2,820	2,820	2,820
Math test score	0.187*	0.298**	0.434***	0.176*	0.297**	0.407***	**0.168***	0.290**	0.396***	0.163*	0.281**	0.398***
	(0.101)	(0.124)	(0.159)	(0.100)	(0.122)	(0.155)	**(0.100)**	(0.120)	(0.150)	(0.098)	(0.117)	(0.144)
Observations	1,091	1,091	1,091	1,130	1,130	1,130	**1,226**	1,226	1,226	1,281	1,281	1,281
	Bandwidth = 220 grams			Bandwidth = 230 grams			Bandwidth = 240 grams			Bandwidth = 250 grams		
28-day mortality	-0.031*	-0.066***	-0.104***	-0.031*	-0.063***	-0.103***	-0.030*	-0.060***	-0.102***	-0.030*	-0.058***	-0.099***
	(0.018)	(0.022)	(0.024)	(0.017)	(0.022)	(0.024)	(0.017)	(0.022)	(0.023)	(0.017)	(0.022)	(0.023)
Observations	2,947	2,947	2,947	3,087	3,087	3,087	3,205	3,205	3,205	3,454	3,454	3,454
1-year mortality	-0.028	-0.077***	-0.108***	-0.025	-0.073***	-0.107***	-0.023	-0.069***	-0.107***	-0.022	-0.065***	-0.107***
	(0.021)	(0.025)	(0.030)	(0.020)	(0.025)	(0.030)	(0.020)	(0.025)	(0.029)	(0.019)	(0.025)	(0.028)
Observations	2,947	2,947	2,947	3,087	3,087	3,087	3,205	3,205	3,205	3,454	3,454	3,454
Math test score	0.161*	0.268**	0.395***	0.161*	0.252**	0.392***	0.163*	0.236**	0.385***	0.165*	0.222**	0.376***
	(0.097)	(0.114)	(0.140)	(0.096)	(0.112)	(0.137)	(0.094)	(0.110)	(0.134)	(0.093)	(0.109)	(0.131)
Observations	1,345	1,345	1,345	1,427	1,427	1,427	1,491	1,491	1,491	1,616	1,616	1,616

Appendix Table A8: Robustness to choice of bandwidth and degree of polynomial in birth weight, all focal children with gestational age of at least 32 weeks (cont'd)

	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3	Poly 1	Poly 2	Poly 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bandwidth = 260 grams			Bandwidth = 270 grams			Bandwidth = 280 grams			Bandwidth = 290 grams		
28-day mortality	-0.029*	-0.056**	-0.096***	-0.028*	-0.055**	-0.094***	-0.027*	-0.053**	-0.092***	-0.026*	-0.052**	-0.089***
	(0.016)	(0.022)	(0.023)	(0.016)	(0.022)	(0.023)	(0.016)	(0.022)	(0.023)	(0.015)	(0.022)	(0.023)
Observations	3,582	3,582	3,582	3,699	3,699	3,699	3,846	3,846	3,846	3,979	3,979	3,979
1-year mortality	-0.020	-0.061**	-0.105***	-0.019	-0.058**	-0.103***	-0.018	-0.056**	-0.100***	-0.016	-0.053**	-0.098***
	(0.019)	(0.024)	(0.028)	(0.019)	(0.024)	(0.027)	(0.018)	(0.024)	(0.027)	(0.018)	(0.024)	(0.026)
Observations	3,582	3,582	3,582	3,699	3,699	3,699	3,846	3,846	3,846	3,979	3,979	3,979
Math test score	0.162*	0.219**	0.354***	0.159*	0.217**	0.337***	0.156*	0.216**	0.323**	0.154*	0.213**	0.312**
	(0.092)	(0.108)	(0.129)	(0.091)	(0.107)	(0.127)	(0.090)	(0.107)	(0.126)	(0.089)	(0.106)	(0.124)
Observations	1,685	1,685	1,685	1,736	1,736	1,736	1,798	1,798	1,798	1,867	1,867	1,867
	Bandwidth = 300 grams											
28-day mortality	-0.026*	-0.051**	-0.086***									
	(0.015)	(0.022)	(0.022)									
Observations	4,357	4,357	4,357									
1-year mortality	-0.015	-0.050**	-0.096***									
	(0.018)	(0.024)	(0.026)									
Observations	4,357	4,357	4,357									
Math test score	0.150*	0.215**	0.294**									
	(0.088)	(0.105)	(0.122)									
Observations	2,027	2,027	2,027									

Notes: Sample of all focal children with gestational age of at least 32 weeks and birth weight within a bandwidth around the 1,500g cutoff indicated in panel headings. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A9: Additional robustness checks, focal children with siblings and with gestational age of at least 32 weeks

	Baseline	Including controls	Control for heaping at 50g	Donut sample		Excluding children from multiple births
				Excluding 1,500g	Excluding 1,490g-1,510g	
	(1)	(2)	(3)	(4)	(5)	(6)
28-day mortality	-0.047**	-0.048**	-0.046**	-0.038	-0.040	-0.058**
	(0.023)	(0.022)	(0.023)	(0.026)	(0.025)	(0.029)
Observations	0.062	0.062	0.062	0.056	0.057	0.067
	2,156	2,156	2,156	2,058	2,002	1,718
1-year mortality	-0.048*	-0.046*	-0.048*	-0.044	-0.047	-0.051
Observations	(0.026)	(0.026)	(0.025)	(0.030)	(0.031)	(0.031)
	0.077	0.077	0.077	0.072	0.073	0.083
Math test score	2,156	2,156	2,156	2,058	2,002	1,718
Observations	0.382***	0.381***	0.375***	0.367**	0.164	0.390**
28-day mortality	(0.143)	(0.114)	(0.137)	(0.156)	(0.191)	(0.193)
	-0.259	-0.259	-0.259	-0.236	-0.220	-0.225
Observations	926	926	926	884	849	720

Notes: Sample of focal children with siblings and with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. In addition, the specification in column 2 includes controls for focal child characteristics (gestational age and indicators for gender, parity, plurality, birth year, and birth region) and maternal characteristics (age, years of education, and marital status), and the specification in column 3 includes controls for heaping at 50g intervals. The samples in columns 4 and 5 exclude focal children with birth weight of exactly 1,500g or between 1,490-1,510g, respectively. The sample in column 6 excludes focal children from multiple births. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A10: Additional robustness checks, all focal children with gestational age of at least 32 weeks

	Baseline	Including controls	Control for heaping at 50g	Donut sample		Excluding children from multiple births
				Excluding 1,500g	Excluding 1,490g-1,510g	
	(1)	(2)	(3)	(4)	(5)	(6)
28-day mortality	-0.033*	-0.037**	-0.033*	-0.028	-0.030	-0.041*
	(0.019)	(0.019)	(0.019)	(0.021)	(0.022)	(0.024)
Observations	0.051	0.051	0.051	0.047	0.048	0.059
	2,708	2,708	2,708	2,584	2,510	2,065
1-year mortality	-0.034	-0.037*	-0.034	-0.032	-0.035	-0.038
Observations	(0.022)	(0.022)	(0.022)	(0.025)	(0.028)	(0.027)
	0.067	0.067	0.067	0.062	0.063	0.074
Math test score	2,708	2,708	2,708	2,584	2,510	2,065
Observations	0.168*	0.194**	0.156*	0.156	0.025	0.245*
28-day mortality	(0.100)	(0.084)	(0.092)	(0.111)	(0.134)	(0.138)
	-0.242	-0.242	-0.242	-0.225	-0.217	-0.223
Observations	1,226	1,226	1,226	1,167	1,120	875

Notes: Sample of focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the row in the sample indicated in the column. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. In addition, the specification in column 2 includes controls for focal child characteristics (gestational age and indicators for gender, parity, plurality, birth year, and birth region) and maternal characteristics (age, years of education, and marital status), and the specification in column 3 includes controls for heaping at 50g intervals. The samples in columns 4 and 5 exclude focal children with birth weight of exactly 1,500g or between 1,490-1,510g, respectively. The sample in column 6 excludes focal children from multiple births. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A11: Placebo regressions at different cutoffs, focal children with siblings and with gestational age of at least 32 weeks

	Cutoff									
	1,100g	1,300g	**1,500g**	1,700g	1,900g	2,100g	2,300g	2,500g	2,700g	2,900g
	(1)	(2)	(3)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
28-day mortality	0.075	0.000	**-0.047****	0.003	0.002	0.004	0.004	-0.003	-0.001	-0.001
	(0.071)	(0.027)	**(0.023)**	(0.011)	(0.007)	(0.005)	(0.004)	(0.002)	(0.002)	(0.001)
Mean outcome	0.107	0.079	**0.062**	0.041	0.023	0.015	0.009	0.005	0.003	0.002
Observations	473	1,100	**2,156**	4,005	7,024	11,873	20,687	36,945	65,752	111,061
1-year mortality	0.051	-0.004	**-0.048***	-0.019	0.004	0.004	0.004	-0.004	0.000	-0.000
	(0.072)	(0.025)	**(0.026)**	(0.013)	(0.010)	(0.007)	(0.004)	(0.003)	(0.002)	(0.002)
Mean outcome	0.127	0.101	**0.077**	0.058	0.034	0.023	0.016	0.010	0.008	0.006
Observations	473	1,100	**2,156**	4,005	7,024	11,873	20,687	36,945	65,752	111,061
Math test score	0.581*	0.012	**0.382*****	0.001	-0.037	-0.069	-0.043	0.064*	0.037	0.010
	(0.316)	(0.266)	**(0.143)**	(0.088)	(0.063)	(0.062)	(0.046)	(0.033)	(0.029)	(0.021)
Mean outcome	-0.386	-0.264	**-0.259**	-0.214	-0.187	-0.199	-0.182	-0.198	-0.148	-0.082
Observations	169	452	926	1,875	3,545	6,317	11,221	20,567	37,591	64,733

Notes: Sample of focal children with siblings and with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the cutoff indicated in the column heading. Each cell represents the coefficient of an indicator variable for birth weight less than the cutoff from a separate regression of the outcome variable listed in the row. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Appendix Table A12: Placebo regressions at different cutoffs, all focal children with gestational age of at least 32 weeks

	Cutoff									
	1,100g	1,300g	**1,500g**	1,700g	1,900g	2,100g	2,300g	2,500g	2,700g	2,900g
	(1)	(2)	(3)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
28-day mortality	0.069	-0.005	**-0.033***	0.002	0.002	0.004	0.005	-0.003	-0.001	-0.001
	(0.070)	(0.021)	**(0.019)**	(0.008)	(0.006)	(0.004)	(0.004)	(0.002)	(0.002)	(0.001)
Mean outcome	0.086	0.064	**0.051**	0.034	0.019	0.013	0.008	0.004	0.003	0.002
Observations	593	1,390	**2,708**	5,027	8,663	14,316	24,560	43,042	75,189	124,805
1-year mortality	0.049	-0.008	**-0.034**	-0.011	0.005	0.003	0.005	-0.002	0.001	-0.000
	(0.071)	(0.020)	**(0.022)**	(0.010)	(0.008)	(0.006)	(0.004)	(0.002)	(0.002)	(0.002)
Mean outcome	0.102	0.083	**0.067**	0.048	0.029	0.021	0.014	0.009	0.008	0.005
Observations	593	1,390	**2,708**	5,027	8,663	14,316	24,560	43,042	75,189	124,805
Math test score	0.047	-0.161	**0.168***	-0.101	-0.016	-0.066	-0.013	0.053*	0.027	0.013
	(0.336)	(0.183)	**(0.100)**	(0.085)	(0.059)	(0.043)	(0.041)	(0.028)	(0.030)	(0.021)
Mean outcome	-0.314	-0.239	**-0.242**	-0.164	-0.172	-0.171	-0.162	-0.184	-0.137	-0.078
Observations	237	614	**1,226**	2,452	4,471	7,678	13,339	23,927	42,747	72,140

Notes: Sample of focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the cutoff indicated in the column heading. Each cell represents the coefficient of an indicator variable for birth weight less than the cutoff from a separate regression of the outcome variable listed in the row. All regressions use a triangular kernel and control for a polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table A13: Effects on family resources, all focal children with gestational age of at least 32 weeks

	(1)	(2)	(3)	(4)	(5)	(6)
	Mother's income, by age of focal child		Father's income, by age of focal child		Total family income, by age of focal child	
	0-5 years	6-10 years	0-5 years	6-10 years	0-5 years	6-10 years
VLBW	-4662.982	-392.278	16323.329	28496.081*	11019.495	27096.347
	(11110.190)	(11631.557)	(14085.577)	(15490.118)	(20716.975)	(22144.230)
Mean outcome	117,776	147,801	219,951	236,754	330,719	372,946
Observations	2,699	2,657	2,641	2,593	2,705	2,686
	Mother's employment, by age of focal child		Mother's days worked, by age of focal child		Maternity leave	
	0-5 years	6-10 years	0-5 years	6-10 years	(days)	
VLBW	-0.037	0.008	-2.774	-0.625	9.175	
	(0.030)	(0.031)	(10.239)	(10.768)	(8.699)	
Mean outcome	0.883	0.848	125.041	149.589	157.176	
Observations	2,698	2,654	2,698	2,654	1,672	
	Father's employment, by age of focal child		Father's days worked, by age of focal child			
	0-5 years	6-10 years	0-5 years	6-10 years		
VLBW	-0.017	0.040	1.780	8.469		
	(0.030)	(0.042)	(9.895)	(9.902)		
Mean outcome	0.912	0.864	182.754	183.049		
Observations	2,640	2,592	2,640	2,592		

Notes: Sample of all focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.

Table A14: Effects on family environment, all focal children with gestational age of at least 32 weeks

	(1)	(2)	(3)	(4)	(5)	(6)
	Mother's use of antidepressants, by age of focal child			Father's uses antidepressants, by age of focal child		
	2-5 years	6-10 years	11-15 years	2-5 years	6-10 years	11-15 years
VLBW	-0.023	-0.014	-0.005	0.019	0.023	-0.011
	(0.022)	(0.019)	(0.019)	(0.030)	(0.021)	(0.030)
Mean outcome	0.037	0.041	0.054	0.030	0.044	0.067
Observations	908	2,005	2,707	882	1,965	2,653
	Intellectual disability by age 5	Behavioral/emotional disorders by age 10	ADHD by age 10	Divorce by age 10		
VLBW	-0.012	0.008	0.000	0.084**		
	(0.008)	(0.011)	(0.006)	(0.039)		
Mean outcome	0.011	0.017	0.007	0.295		
Observations	2,708	2,708	2,708	2,653		

Notes: Sample of all focal children with gestational age of at least 32 weeks and birth weight within a 200g bandwidth around the 1,500g cutoff. Each cell represents the coefficient of the *VLBW* variable from a separate regression of the outcome variable listed in the column. All regressions use a triangular kernel and control for a first-degree polynomial in birth weight (allowed to differ on both sides of the cutoff) and heaping at 100g intervals. Standard error clustered at the gram level reported in brackets. *** significant at 1%, ** at 5%, * at 10%.