The Role of Early Life Health Interventions on Mortality and Academic Achievement

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Abstract

In this paper we examine the role of early childhood health interventions on mortality and long run academic achievement in school. We exploit the idea that medical treatments often follow rules of thumb for assigning care to patients. In this instance we use the cutoff of Very Low Birth Weight (VLBW) that assigns infants below 1500 grams to extra treatments. Using detailed administrative data on schooling and vital statistics from Chile, we find that children who receive extra medical care at birth are more likely to survive and obtain scores that are between 0.1 and 0.2 SD higher in language and math. In addition we exploit the timing of Chile's national surfactant policy which was introduced in 1998 to provide evidence that this specific policy had a large impact on both mortality and academic achievement. Our results are robust to a wide variety of regression discontinuity design checks, including those which address empirical design concerns arising from irregular heaping of data which could occur in the case of birth weight data.

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1 Introduction

Do early life health interventions affect outcomes later in life? The question is of immense importance not only due to the significant efforts currently being made to improve early childhood health world wide, but also due to large disparities in neonatal and infant health care that remain between and within countries.[1] While the stated goal of many such interventions is to improve childhood health and reduce infant mortality, understanding spillovers such as better academic achievement is key to estimating their efficacy. In addition to the policy relevance of such an exercise, we can also learn about the health-income gradient by examining the role of health interventions on academic outcomes. In an influential article, Case, Lubotsky, and Paxson (2002) suggest that the origins of the health-income gradient in adulthood has its origins in childhood health. Understanding the link between early life health interventions and school performance can shed light on a potential mechanism for why a link between childhood health and adult outcomes might exist.

Examining the role of early life health interventions in explaining academic achievement also gives us some key insights into the education production function. The recent literature on educational production functions tends to find that a large part of the variation in educational outcomes is explained by students' individual "initial conditions" (Almond and Currie 2010, Heckman and Masterov 2007). Successful early life health interventions would suggest that initial conditions of students are not only a function of family and individual choices, but also of public policies such as health care.[2] As we will show in this paper, the fact that treatments at birth make a difference suggest that the observed heterogeneity in educational outcomes can in part be explained by heterogeneity in health care beginning at birth. By focussing on the role of healthcare policy, such as the introduction of standardized neonatal care in Chile during the 1990s, we underscore the importance of early life healthcare as a way to improve test scores and potentially lower inequalities in achievement.[3]

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[1] World Health Report (2005) documents the persistent gaps in provision of care which consequently leads to largely avoidable deaths of over 4 million babies before they reach the age of 28 days and half a million mothers at childbirth. This is considerably more than infant deaths caused by malaria and AIDS together.

[2] An excellent reference is Currie (2006) where examples from many well known public safety net programs and their impact on child well being is discussed.

[3] A small sampling of studies that examine the role of early life health and school outcomes are Miguel and Kremer (2004), Bleakley (2007), Behrman (1996), Glewwe, Jacoby, and King (2001), Maccini and Yang (2009) and Field, Robles, and Torero (2009). Most of these papers however, examine interventions that are contemporaneous with observed educational outcomes. In the seminal work on educational externalities of health interventions by Miguel and Kremer (2004), the intervention examined is contemporaneous with school outcomes. Field, Robles, and Torero (2009) find that children born to mothers subjected to an iodine supplement program while pregnant complete more years of schooling. In spirit, this paper is quite close to

The usual challenge in examining the causal link between health interventions and school outcomes is that interventions are not administered randomly. Hence, infants who receive special medical attention might be different along various other dimensions that might affect mortality and school performance. To get around such confounding factors, we adopt the idea used in Almond, Doyle, Kowalski, and Williams (2010) (henceforth ADKW) and take advantage of rules and recommendations for administering medical care to children who are born with Very Low Birth Weight (VLBW - birth weight less than 1500 grams). The underlying assumption is that an infant born with a birth weight of 1490 grams is essentially identical to an infant born with a birth weight of 1510 grams, except for the extra medical attention that one infant might receive, simply because he/she was born below a somewhat arbitrary cutoff. At these close margins the role of confounding factors is mitigated and inference can be carried out at least locally through a regression discontinuity design.

Rules and recommendations regarding VLBW births appear to be quite salient in Chile. In guidelines published by the Ministry of Health in Chile, the medical recommendations for children born below 1500 grams are explicitly stated and eligibility for several publicly funded treatments are determined by birth weight and gestational age. For example, treatments for broncopulmonary displasia (a chronic lung disorder that affects newborns) under the AUGE program (Regime of Explicit Health Guarantees) and the PNAC program (Nutritional Supplements for Premature Infants) explicitly state birth weight (less than 1500 grams) and/or gestational age (less than 32 weeks) criteria as the sole determinants for eligibility of coverage.[4] We focus in particular on the birth weight cutoff since gestational age is measured at weekly intervals and is hence not a suitable running variable. Birth weight on the other hand is measured at the gram interval and we can thus compare children just under and over 1500 grams to examine differences in outcomes as a result of extra medical treatments.

Using data on the population of births between 1992-2007 matched with infant and neonatal mortality, we find compelling evidence that differential treatments had a significant impact on 24 hour, neonatal and infant mortality rates. Specifically we find that mortality rates are *lower* for infants born just below the cutoff compared to infants born just above. We find that children born just below the cutoff have around 4.5 percentage point lower infant mortality rates and 1.9 percentage point lower 24 hour mortality rates. These effects

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theirs, although we examine school achievement rather than years of attainment. Perhaps more closely related to the current study is a recent paper by Chay, Guryan, and Mazumder (2009). They relate the narrowing of the black-white test score gap in the US to improved health access for blacks during infancy after the Civil Rights Act.

[4] See section 3 for more detail on these and other policies relevant to the birth weight cutoff.

are quite large considering the mean infant and 24 hour mortality rate of around 12% and 4% for children born between 1400-1600 grams. The results are also large when compared with those found by ADKW for the US.

Using the population of births between 1992-2002 matched to their school outcomes in Chile for the period of 2002-2008, we find that children born just below the 1500 gram cutoff have math and language grades (standardized at the classroom level) that are on average 0.2 and 0.1 SD higher than kids born above the cutoff in spite of the general positive relationship between birth weight and academic achievement. We confirm our findings using a second source of academic achievement, a national standardized test known as the SIMCE and similar magnitudes are found for both math (0.17 SD) and language (0.1 SD).

We also analyze a direct policy initiative aimed at reducing deaths among preterm and underweight infants. In 1998, Chile introduced universal surfactant therapy (used to combat respiratory distress, which commonly occurs in VLBW and LBW infants) to be administered to children who were born at risk and with very low birth weights. Using the timing of the policy together with the regression discontinuity framework described above, we find suggestive evidence that the introduction of this policy augmented the effect of being just below the cutoff, reducing mortality and raising academic outcomes even more. [5]

An important aspect of interpreting our findings as the impact of medical interventions alone is to assume that parental investments or behavior does not change as a result of early life treatments. This is a feature common to nearly all papers examining long run outcomes of early life shocks or treatments and disentangling the effects are quite challenging (Almond and Currie 2010). For a small subsample of the data, we find that parents of children born below the cutoff spend similar resources in terms of parental time (on activities such as reading, helping with homework etc) as do parents of children born just above the cutoff. Moreover, children born below the cutoff do not appear to be enrolled in schools of observably different qualities. Hence, we provide suggestive evidence that the role of parental responses to medical treatment in this setting might be limited.

Our identification strategy hinges on the idea that children born just below and just above the cutoff are practically identical along observed and unobserved dimensions. While our results are robust to all the standard regression discontinuity checks, studies that use birth weight as a running variable have to consider problems associated with non-random heap-

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[5] The medical literature has considered the introduction of surfactant as a primary reason for the decline in mortality after 1998 (Gonzalez et al 1998).

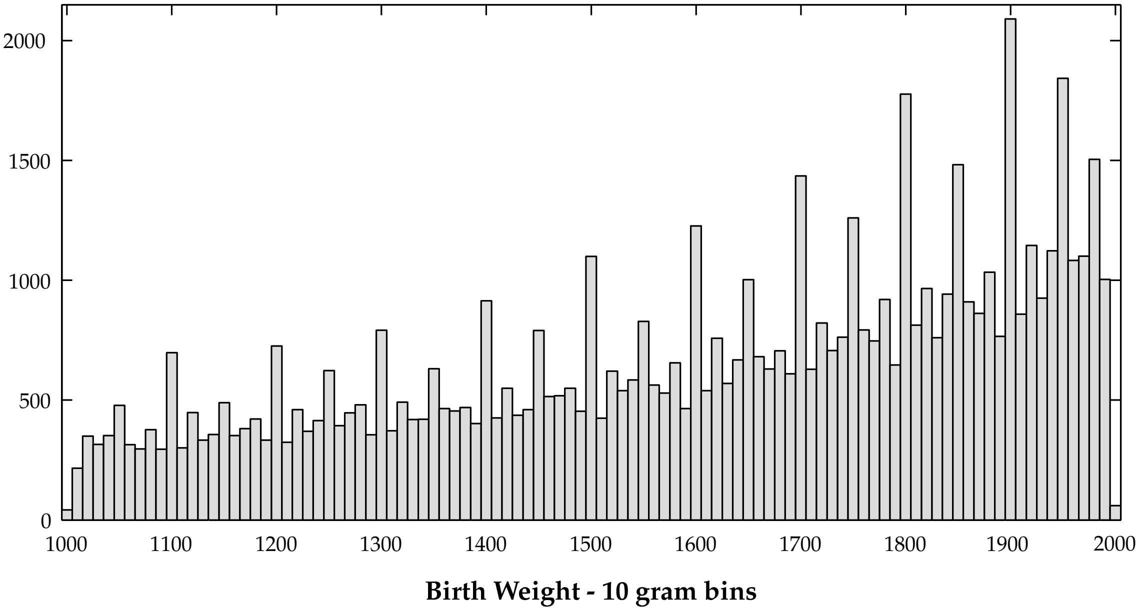
ing of birth weight at certain integer values (for example multiples of 50 or 100). We show that in the case of Chile, while rounding is correlated with some observable characteristics at multiples of 50 and 100, the main results are similar when we adopt a donut regression discontinuity design to account for any potential bias due to abrupt compositional change at natural heaping points as recommended by Barreca et al (2011). We have an important additional check in our setting. As mentioned earlier, the rules and recommendations in Chile explicitly mention a 32 week gestational rule: all children (regardless of birth weight) below 32 weeks of gestation are eligible for treatments. If the socioeconomic characteristics associated with heaping or rounding were an important aspect of the results, then even for the sample below 32 weeks in age, we should find that birth weight cutoffs matter. Birth weight cutoffs play no role in determining mortality or test scores for children who were born with less than 32 weeks of gestation.

The rest of this paper is organized as follows. Section 2 describes the data and some stylized facts about mortality in Chile. Section 3 provides some background on VLBW births in Chile, and highlights some of the guidelines for taking care of VLBW infants. Section 4 discusses the economic model which highlights the benefits and limitations of the regression discontinuity design used in this paper. Section 5 presents the main results on mortality and school outcomes and section 6 discusses the battery of robustness checks, including accounting for ”heaping” in birth weight data as recently suggested by Barreca et al (2011). Section 7 briefly discusses other related outcomes such as parental investments and Section 8 concludes.

2 Data and Stylized Facts

The data we use comes by matching the population of births between 1992-2007 to death certificate data for the same years and school and test score records between 2002-2008. As most children in the later years of the data are too young to be observed in school, we use births between 1992-2002 for our main sample. The data on the birth weight and background information of parents comes from a dataset provided by the Health Ministry of the Government of Chile. This dataset provides data on the sex, birth weight, birth length, weeks of gestation and several demographics of the parents such as the age, education and occupational status. In addition, the dataset provides a variable describing the type of birth, be it a single birth, double (twins), triple (triplets), etc. Mothers of births in this part of the birth weight distribution are surprisingly similar to the average. They have similar education levels, age, and are only slightly less likely to be married at the time of birth. Births in this range however are much more likely to be multiple. Between 1400g-1600g, 15% of births were twins or triplets, which is much higher that the population average of 1.6%. See Table A-1 for more characteristics of VLBW births in this sample.

Figure 1: Histogram of Birth Weight - 1000g to 2000g

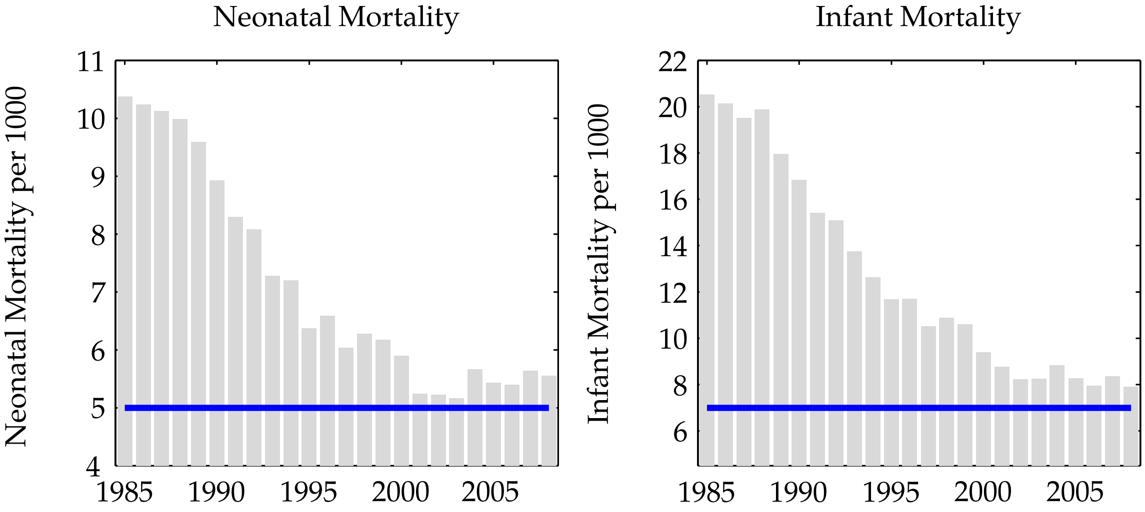


Note: This figure shows a histogram of the birth weight distribution between 1000g and 2000g. The bins have width 10g.

2.1 Mortality Data

We obtain death records (by age) from the Health Ministry as well. The merged births and deaths database accounts for virtually all officially recorded births and deaths (99%) during this period. Both neonatal and infant mortality dropped significantly during the time period between 1992-2007. Figure 2 shows the convergence in infant and neonatal mortality to current US levels by the early 2000s. In addition, a significant part of the reduction in mortality occurred among VLBW births and specifically in the birth weight range of interest. The medical literature has largely credited the implementation and expansion of neonatal care in public hospitals and in particular the introduction of surfactant We find that on average 13% of births between 1000g-2000g die before reaching school age: 18% in 1992 and 9% in 2002.

Figure 2: Infant and Neonatal Mortality Rates in Chile, 1985-2008



Note: Infant mortality is defined by the amount of deaths before the age of 1 per 1000 births. Neonatal mortality is defined by the amount of deaths before the age of 28 days per 1000 births. The blue line represents the 2009 level in the USA (World Bank Economic Indicators) which was 7 infant deaths per 1000 births and 5 neonatal deaths per 1000 births. To put the fall of mortality into context, in terms of infant mortality, in 1985 Chile had a rate comparable to the current rate in Ecuador (20), Nicaragua (22) or Peru(19).

2.2 Academic Achievement Data

The data on academic achievement comes from two sources. The first is a national test administered to 4th and 8th grade students in Chile called the SIMCE. Due to the age range for which we observe births, we can feasibly only use the 4th grade scores. The vast majority of students take this test and test absence is extremely low. The match rate between vital statistics and 4th grade SIMCE is approximately 90%. In spite of this, the amount of observations in the VLBW range is limited because it was not administered every year to 4th graders. We only observe SIMCE scores and vital stats from 2002, and 2005-2008. Within the birth weight range of 1400g-1600g we are able to observe around 1800 observations for 4th grade math. Of these approximately 1000 births were above 32 weeks of gestation.

A second data set on school achievement comes from administrative data on the classroom grades of the population of students between 2002 and 2008. This database was provided by the Ministry of Education of Chile (MINEDUC). The database on academic performance in school consists of the grades by subject of each student in a given year. We standardize grades for each student at the class room level since we have the grades of all students in a given classroom.

2.3 Matching all data sets

We observe approximately 4 million births between 1992 and 2007, out of which approximately 0.9% (38,000 births) are observed to be below 1500 grams in birth weight and are considered VLBW. Within the bandwidths we examine in this paper (between 1400 and 1600 grams) we observe approximately 13,000 births. Among these 13,000 births about 7,230 births are for infants who are above 32 weeks of gestation (inclusive). More than 95% of all births within the appropriate age range (born between 1992-2002) are matched to their educational records. Table A-3 presents the outcome of the merge between vital stats and educational records taking into account the births that have not survived until schooling age. Consistent with the incidence of mortality in this birth weight range, we find that more observations are lost to the death of the child (14%) than to missing data (5%).

3 VLBW births in Chile and birth weight cutoffs

Health care in Chile is primarily funded by the public system and approximately 75% of the population uses the public insurance system (Palomino, Morgues, and Martinez 2005). This national health system has 26 regions, and each region has at least one hospital with a Neonatal Intensive Care Unit (NICU), which are equipped for providing specialized care to VLBW infants (Gonzalez et al 2006). Moreover, according to Gonzalez et al (2006), due to a national committee of Chilean neonatologists, since 1991 the standards for care and equipment are the same across all NICUs in the country. As a consequence, the study points out that, "A protocol has been implemented at the national level to regulate the referral of neonates who are born in hospitals without a NICU to the regional hospitals. There also are *standardized protocols for the treatment of newborns who weigh less than 1500g* and for cases of respiratory distress syndrome" (emphasis added). Relevant to our study, approximately 68% of births occur in hospitals with a NICU, and the number of NICU's in the country did not change between 1992-2000 (Gonzalez et al 2006).

Publications put out by the Ministry of Health in Chile list the numerous medical recommendations to be administered to children who are born with a weight of less than 1500 grams and/or less than 32 weeks in gestational age. These include, but are not limited to:

examination by a neonatologist, a 5 day check up, various X-rays and other forms of specialized care.[6] One of the most well known programs introduced in Chile was the national surfactant program in 1998. Under this program artificial lung surfactant is used to treat respiratory distress syndrome in VLBW infants. Many public health articles on Chile's infant and neonatal mortality give credit to this program in reducing mortality rates among VLBW infants in Chile (Jimenez and Romero 2007, Gonzalez et al 2006). In addition, the Ministry of Health began to collect data and follow all births under 1500g and/or 32wk of gestation and asked for hospitals and clinics to report these when they occurred. A manual was published in 1999 with the title including the 1500g cutoff and 32wk gestational period again signaling the importance of the cutoff.[7]

Several public neonatal health care programs that were introduced during this period went even further and not only recommended treatments for births under the cutoff but made the eligibility under the public health care system an explicit requirement. The PNAC is a program introduced in 2003 which provides nutritional supplements (fortified milk) for premature births for one year. This program has the eligibility determined exclusively by the cutoff birth weight and gestational age. A larger public health care expansion called AUGE provided three additional neonatal examinations and treatments to VLBW births. These include i) screening for Retinopathy of Prematurity (ROP), which helps avoid blindness, ii) screening and followup treatment for Sensorineural Hearing Loss (SHL), and iii) treatment for Bronchopulmonary Dysplasia (BPD) which is a chronic lung disease common in VLBW births. Eligibility for these is also determined by the birth weight cutoff. The medical literature cites BPD and early childhood lung diseases to be significantly correlated with cognitive outcomes (Singer et al 1997, D'Angio et al 2002, Marlow et al 2005). One of the pathways by which preterm birth might affect cognitive outcomes appear to be related to the development of the lung and the delivery of oxygen to the brain. Hypoxia (reduction in oxygen supply to tissues) or ischemia (a severe low oxygen state) in the perinatal period is one of the leading causes of brain injury in preterm infants (Luciana 2003).

These policies and recommendations show a general trend in which the medical community in Chile gives a special importance to the births below the weight of 1500g. In sum, it appears that the "rules of thumb" as mentioned in ADKW are very much present in the Chilean context. Moreover, due to universal health care and "official" policies surrounding

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[6] For a full translated transcript of some of the recommended guidelines please email the authors. A website maintained by the Committee of Neonatologists in Chile provides extensive information (www.prematuros.cl).

[7] This manual is titled "Orientaciones Tecnicas para el seguimiento del recien nacido <1500 y/o <32 semanas al nacer" which translates to "Technical Orientations for Births Below 1500 grams and or 32 Weeks of Gestation." This is available in PDF form from the authors.

the treatment of VLBW infants, we expect such rules of thumb to be implemented more rigorously than in the United States.

4 Economic Framework

This section describes a basic framework where families invest in the health and education of their children both as a function of preferences and wealth but also in reaction to shocks. The model will be useful to highlight both the advantages of the regression discontinuity framework in this context as well as the main limitations inherent to the questions we wish to address.

4.1 Health at Birth and Neonatal Mortality

Health at birth is assumed to be a function of investments made prior to birth and a random component. Birth weight (*BW*) is assumed to be a noisy signal of initial health.

$$H_{i0} = h_0 + I^{\text{pre}}(w_i, \theta_i) + e_i \tag{1}$$

$$= \text{BW}_i + \nu_i \tag{2}$$

Investments made during the gestational age are assumed to be a function of family resources w and preferences θ. We keep this additional notation to emphasize the complexity and heterogeneity inherent to families' investment function. Investments after birth differ by including the underlying health of the child at that time, thus correlated to past investments through family characteristics but also reacting to any later shocks. In addition, investments post birth have a component $D(BW, c)$ which is determined stochastically as a function of BW_i and a cut off c. This represents the collection of treatments which might be influenced by both official and rule of thumb behavior by midwives, doctors and clinics regarding the needs of very low weight births which is defined by an arbitrary cutoff of birth weight c.

$$I_1^{\text{post}} = I(w, \theta, H_0) + \gamma D(BW, c) \tag{3}$$

The probability of a birth getting extra treatment is shifted upwards by κ below the cutoff c. This assumption is key for the empirical framework as it will generate a discrete jump in the probability of $D = 1$ at c. v_i is white noise and $g(.)$ is a decreasing function of initial health H_0.

$$D(BW, c) = 1\left[g(H_{0i}) + \kappa(BW_i < c) + v_i > 0\right] \tag{4}$$

Let survival past the 28th day of life be described by the following probability model:

$$y_i \quad = \quad 1\left[\phi\left(h_0 + I^{\text{pre}}(w, \theta) + e_i\right) + \beta I^{\text{post}}(w, \theta, H_{i0}) + \beta\gamma D_i + \epsilon_i > 0\right] \tag{5}$$

Replacing $BW_i + \nu_i$ for initial health, we have the following expression for the probability of neonatal survival which is the objective of empirical interest:

$$y_i \quad = \quad 1\left[\phi\left(BW_i + \nu_i\right) + \beta I^{\text{post}}\left(w, \theta, BW_i + \nu_i\right) + \beta\gamma D_i + \epsilon_i > 0\right] \tag{6}$$

This framework highlights two distinct problems for empirical work. The first is that investments are partially unobserved and correlated with initial health through family characteristics such as resources and preferences. In addition, notice that post investments react to the true underlying health of the birth H_{i0} while we only observe BW which is a noisy proxy. Even if we observed investments we would worry that they would be endogenously associated to the unobserved underlying health condition ν_i again confounding empirical analysis.

4.2 RD design for neonatal mortality

While post investments and treatments received are determined as a function of underlying health, a part of the investment after birth is given with a probability that makes a discrete jump at $BW_i = c$.

Taking the difference of the limits of the expectation of y_i from above and below we can write the following:

$$\lim_{BW\uparrow c} E\left[y_i \middle| BW_i\right] - \lim_{BW\downarrow c} E\left[y_i \middle| BW_i\right] = \beta\gamma \cdot \left[\lim_{BW\uparrow c} Pr(D = 1 \middle| BW_i) - \lim_{BW\downarrow c} Pr(D = 1 \middle| BW_i)\right] \tag{7}$$

The direct role of post investments and how they vary with unobservable family characteristics and unobserved health cancel out at the cutoff because they are not systematically different on either side of c. This follows from the fact that post investments are not a function of anything that occurs after birth, in particular they are independent of D. Given this assumption, we have that the local RD estimation recovers the reduced form of the direct effect of the treatment on survival per unit of investment β, multiplied by the intensity of the treatment γ and multiplied by the difference in probabilities of treatment at the cutoff.

Thus by exploiting the discrete jump in treatment probabilities at $BW = c$ we can avoid the confounding factors mentioned above and estimate at least a local reduced form policy effect of treatment given by D on neonatal mortality. This has effectively removed the problems of correlated observable and unobserved investments as well as the endogenous response of investments to unobservable health.[8]

4.3 Health at Birth and Academic Outcomes

Current academic achievement is assumed to be a function of initial health, post investments in health and education as well as a random component which may potentially be serially correlated.Investments are again a function of family characteristics and the current state of health and educational ability. Given these assumptions we can write academic ability as follows:

$$A_{it} = \quad \varphi_t \left(BW_i + \nu_i\right) + \psi_t D + \Gamma(H_{i0}, D, v(i,t), w, \theta) + \omega_{it}^{A}$$

Where $\Gamma(H_{i0}, D, v(i,t), w, \theta)$ is a function of all previous investments (including D), all prior shocks $v(i,t)$ as well as initial health H_{0i}. Notice that this implies that the treatment D affects outcomes in t directly through ψ_t and indirectly through Γ. Finally, we assume academic ability translates into test scores in a simple way: $T_{it} = A_{it} + \epsilon_{it}$.

We can see that attempts to estimate the effect of treatment D has several of the same problems as the prior case of neonatal mortality, namely initial health and observed birth weight are correlated with unobserved investments. Investments react to the unobservable

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[8] In addition, a lower bound on the effect can be found by assuming a sharp discontinuity at c which would set $\Delta = \beta\gamma$.

health component v_i making observed investments correlated with the error term. We have seen that these problems can be solved at least locally by exploiting the discrete jump in the probability of treatments D through an RD design.

However in addition to these problems we have two additional limitations which will not be solved directly through the RD framework and are important for the interpretation of the results from our empirical RD strategy. The first limitation is that households, schools and society in general have a lot of time to adjust investments in response to the arbitrary assignment of treatment D around the cut off. If the original effect is large enough to begin with, it could generate a compensating or reinforcing reaction from investments. Thus the way $\Gamma(D, w, \theta)$ responds to D will be important when interpreting the reduced form policy effect we recover in the empirical section. This is of course natural in any long run outcome but is worth highlighting when interpreting the empirical results as we will not recover be able to recover ψ_t. The second limitation is that we observe the academic outcomes for a selected sample of those students who survived to schooling age. The differential mortality found at the cutoff will make the composition of both groups different and potentially bias estimation.

4.3.1 Later investments reacting to treatments

In this subsection we assume that selection is not an issue and study how the treatment D and later investments affect our results around the cutoff when we use an RD framework. Notice that while w, θ, v are all continuous at the cutoff by assumption, given investments react to the treatment D, $\Gamma(D, \cdot)$ is not. This implies that the investment function Γ will not necessarily be smooth across the cutoff as it might possibly react to the treatment. In particular we have that

$$\lim_{BW \uparrow c} E\left[\Gamma(H_{i0}, D, v(i,t), w, \theta) \middle| BW\right] - \lim_{BW \downarrow c} E\left[\Gamma(H_{i0}, D, v(i,t), w, \theta) \middle| BW\right] \neq 0.$$

The sign of this difference will be informative regarding the bias we will have in our estimates of the direct effect of D on test scores. If Γ exhibits compensating behavior so that $D = 0$ induces higher investments later on, we would expect to understate the role of treatments given by D and part of the difference will be undone by differential investments through Γ. The opposite would be true if investments reinforced differences induced by the treatment D. [9] In either case the resulting effect can be interpreted as the reduced form

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[9] Bharadwaj, Eberhard and Neilson (2011) present suggestive evidence that parents in Chile seem to exhibit compensating behavior in their investments regarding education suggesting a downward bias but given that

equilibrium effect after agents have had time to adjust. Any heterogeneity found in the effect of the policy can also be induced by heterogeneity in the impact of D and Γ.

4.3.2 Sample selection due to mortality

In this section we study the how sample selection affects our results when estimating an RD framework given selection.

Ignoring the role of investments. Taking the expectation of test scores, given survival, we have the following expression:

$$E\left[T_{it}\middle|BW_i, \mathrm{s}\right] = E\left[\varphi_t(BW_i + \nu_i) + \psi_t D\middle|BW_i, \mathrm{s}\right] \tag{8}$$

We expect that given BW_i and D, survivors will have on average better initial underlying health ν_i than the average of the population at birth. In addition, since treatment D lowers the probability of dying conditional on initial health, we also expect the average initial health given BW_i to be worse among the treated group and to differ systematically across the cutoff. To the extend that D affects survival on a different margin than academic outcomes, this selection will generate biased results which persist even at the limit on the cutoff.

4.4 Empirical Design

Our empirical design follows closely that of ADKW and exploits the discrete jump in treatment probability at 1500g to apply a regression discontinuity framework like Imbens and Lemieux (2008) and Lee and Lemieux (2010). We choose a small (100 gram) window around the cutoff of 1500 grams[10] and estimate the following regressions for child i at born at time t:

$$y_i = \eta_1 \mathrm{VL}_i + \eta_2 \mathrm{VL}_i \cdot (bw_i - 1500) + \eta_3(1 - \mathrm{VL}_i) \cdot (bw_i - 1500) + \alpha X_i' + \delta_t + \epsilon_i \tag{9}$$

$$T_i = \beta_1 \mathrm{VL}_i + \beta_2 \mathrm{VL}_i \cdot (bw_i - 1500) + \beta_3(1 - \mathrm{VL}_i) \cdot (bw_i - 1500) + \alpha X_i' + \delta_t + \epsilon_i \tag{10}$$

Γ includes a vast and complicated interaction of inputs this should not be interpreted as definitive evidence.

[10] In the results section we show the sensitivity of the results to various bandwidths between 50 grams and 150 grams at 10 gram intervals.

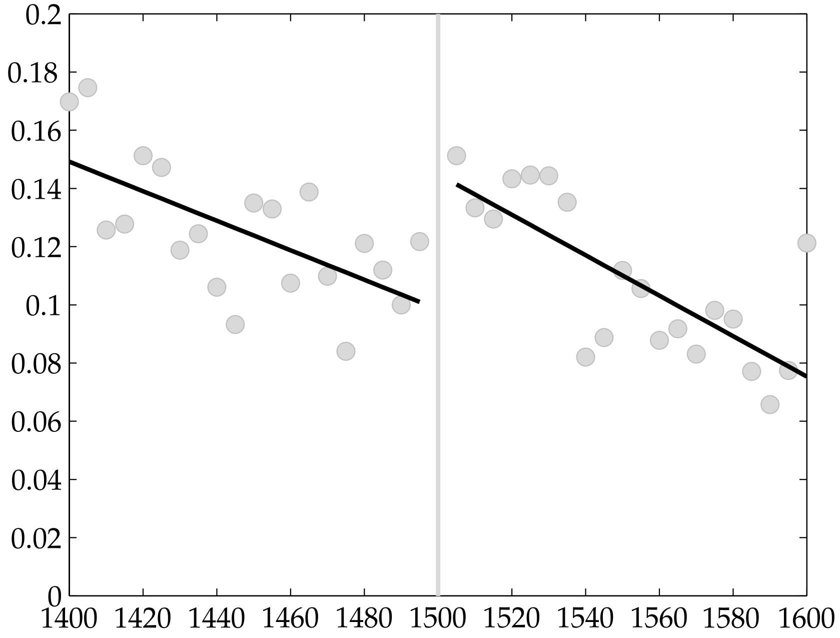
Where y_i is an indicator of survival, T_i is a an academic outcome for child i, VL_i is an indicator which takes on a value of 1 if the child is below 1500 grams and 0 if the child weighs greater than or equal to 1500 grams. We include linear trends above and below the cutoff (in Section 6 we show sensitivity of our results to polynomials around the cutoff). We estimate this regression using OLS and report the coefficients with robust standard errors clustered at the gram level (Card and Lee 2008). In addition, we use triangular weights that assign the points closest to the cutoff the greatest weight. To evaluate the possible impact of the introduction of surfactant in 1998, we estimate the model with the cutoff dummy and the linear trends interacted with an indicator variable equal to one if the year is after 1998.

5 Results

5.1 Neonatal and Infant Mortality

If greater medical care is provided to children just below the cutoff, then it is likely that they will have lower mortality rates than children born just above the cutoff. Using data from 1992-2007, we find that this is indeed the case. Figure 3 shows infant mortality for births around the cutoff and a similar figure is presented in the Appendix for neonatal mortality.

Figure 3: Infant Mortality



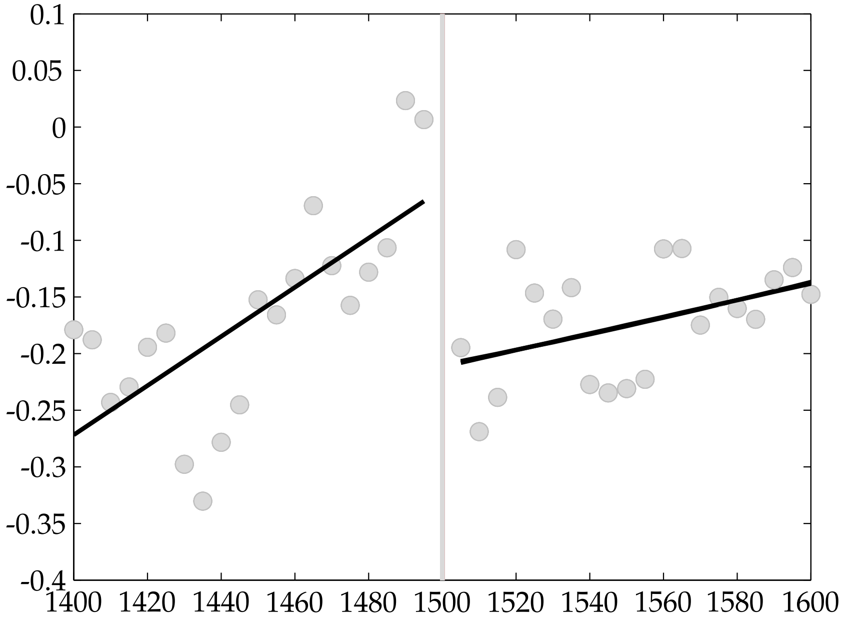
Note: This figure shows average infant mortality for 10 gram bins plotted at every 5 gram intervals. This way, the amount of observations in each bin is similar as all bins include a 10 gram multiple which is where most of the birth weight distribution is rounded to. The solid black line is a third degree polynomial fitted to the data in above and below the cutoff.

Table 1 estimates equation 10 and shows the results for infant and 24 hour mortality by gestational age. As mentioned in section 3, the birth weight cutoff rules are only applicable for children above 32 weeks of gestation. This is because all children below 32 weeks of gestation receive treatment. Confirming our priors, we find that the 1500 gram cutoff is not applicable for children less than 32 weeks in gestational age. Column 2 indicates that children below 1500 grams are 4.5% less likely to die within a year compared to children just above 1500 grams. For 24 hour mortality, the magnitude is around 1.9% in the same direction. These are large effects considering the mean infant and 24 hour mortality rates for this group is 12 and 4%.

5.2 School performance

Figure 4 shows in the simplest terms the basic import of our findings. Children born just to the left of the cutoff perform better in school than children born just to the right of the cutoff, even though birth weight in general is positively related to test score performance.[11]

Figure 4: Academic Achievement around 1500g



Note: This figure shows the average class grades in math from 1st to 8th grade standardized at the classroom level for 10 gram bins plotted at every 5 gram intervals. This way, the amount of observations in each bin is similar as all bins include a 10 gram multiple which is where most of the birth weight distribution is rounded to. The solid black line is a linear trend fitted to the data in above and below the cutoff.

Table 2 estimates Equation 10 in the same setup as Table 2 for mortality.[12] We show that the birth weight cutoffs do not affect test scores for children who were born with a gestational age of less than 32 weeks. However, for children above 32 weeks in gestational age, being to the left of the cutoff implies an increase in math and language scores of 0.2 and 0.1 SD respectively. In the lower panel of Table 2, we use an alternative national test measure (SIMCE) observed at grade 4 for children to show that our results are hold for different types of tests. Unfortunately we do not have SIMCE results from every year that the test was administered - hence, the sample sizes are much smaller for these.

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[11] Since we observe children repeatedly across multiple grades, we simply take the average performance of the child during the period for which we can observe him/her in the data. In Other Table 1, we estimate equation 10 by grade level. We use performance in math as the measure of school performance.

[12] Note that the samples pertaining to mortality are larger than the samples pertaining to academic achievement. This is because children born after 2002 are too young to be observed in our school sample which contains data up to 2008. Average school starting age in Chile is 6 years.

5.2.1 Bias due to selection into survival

The results on differential mortality around the 1500 gram cutoff suggest that there is selection into being observed in school. To the extent that children who survive and children who do not get the same counterfactual test scores in school, our results on academic achievement are free from selection bias. However, this is unlikely as the survivors certainly get different scores. In general we think that the bias would lead to an underestimate of the true effect. This is because the weakest children survive below the cutoff, and these very children might get the worst grades among their birth weight cohort. On the other hand, the weakest children above the cutoff do end up dying, hence, raising the average test scores for those birth weight groups. In Table 3 we offer some counterfactual scenarios where we examine the extent of this bias. We consider pessimistic scenarios and start by assigning non surviving children above 1500 grams the median score of their birth weight group. We subsequently assign the non survivors better and better scores, ranging from the 55th percentile to the 80th percentile within their birth weight group. Under the counterfactual scenario of the non survivors scoring at the 80th percentile (or higher) of their birth weight class, we no longer find evidence for a discontinuity. Hence, the selection into mortality above the 1500 gram mark has to consist of some of the smartest children in their birth weight class for our results to disappear.

5.3 Impact of surfactant program on mortality and academic achievement

As mentioned earlier, in 1998 Chile introduced universal surfactant therapy to be administered to VLBW infants (Gonzalez et al 2006). Table 4 examines the consequences of this national policy which was targeted towards VLBW infants on subsequent mortality and test performance. We find evidence that the surfactant program had a large and positive impact on test scores and further decreased infant mortality below the cutoff. The coefficient of interest in Table 4 is the interaction between the birth cutoff and post 1998 dummy. Under the assumption that the surfactant policy was the *only* change in neonatal service after 1998,[13] Table 4 suggests that children born just below the cutoff but born after 1998 performed even better in math in school. The coefficient on the interaction with infant mortality as the outcome variable is negative and significant, suggesting a further decrease in

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[13] To the best of our knowledge, no major policies were implemented until specialized nutritional programs were introduced in 2003 (PNAC). As a result, the mortality results in Table 4 uses a sample of births between 1992-2003, as opposed to the full sample from 1992-2007. However, in 1999 the Ministry of Health published and distributed a handbook on training programs on the care of VLBW births. This might have also emphasized cutoffs and generated an alternative reason for mortality to improve more under the cutoff after 1998.

infant mortality due to the program. We consider this to be suggestive evidence of the impact of the surfactant policy on test scores and mortality.

As is the case with most regression discontinuity designs, we have to show that our results are robust to a wide variety of robustness checks. In the following section we show that our results are not driven by manipulation of the running variable or non random heaping of data.

6 Robustness Checks

There are two main categories of robustness checks that we perform here: checks that have to do with manipulation of the running variable (a standard concern in most RD designs) and checks that arise due to ”heaping” of data that occurs especially in the case of birth weight.

6.1 Manipulation of the running variable

6.1.1 Histogram of birth weight

One visual way of check for manipulation of the running variable is to simply plot a detailed histogram of the data and to check whether abnormal heaps occur to the left or right hand side of the cutoff. If doctors or parents were systematically manipulating the birth weight variable then we might expect to find many births around 1490 and fewer births around 1510 (say). As can be seen visually in Figure 1 this does not appear to be the case. We test this (as do ADKW) by collapsing the data at the one gram level and testing in a framework similar to equation 9, whether more (or less) births are reported just below the cutoff compared to just above the cutoff. In the above 32 week gestation sample, the coefficient (std. error) on the cutoff dummy is -16.78 (30.33).[14]

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[14] The formal McCrary (2008) test, using an adapted version of DCdensity as obtained from `http://www.econ.berkeley.edu/~jmccrary/DCdensity/DCdensity.ado`, suggests that there is a significant break at 1500 grams, but this is clearly driven by the heap at 1500 grams itself. Moreover, the log difference in height is negative, implying fewer observations to the left of 1500 grams, which is the *opposite* of what we would expect if there were systematic manipulation. On elimination of the 1500 gram point, the test shows no significant break (log difference in height (std error) is -0.0526 (0.0564)). These tests suggest that there is no manipulation of the running variable in this case. As a side note, manipulation in the context of birth weight and medical care is a potential concern as shown to be the case in Japan in a recent working paper by Shigeoka (2011).

6.1.2 The role of covariates

Another standard check with RD designs is that apart from the treatment and outcome variables of interest, no other variables should display discontinuities around the cutoff. In Table 5 we show that a number of demographic characteristics like mother's education, mother's age, mother's employment status et cetera appear smooth around the cutoff of 1500 grams. A graphical equivalent of this is Figure D-3. Were these to show discontinuous jumps, we would be concerned that socioeconomic characteristics determine which side of the cutoff an infant is observed on, invalidating the random assignment assumption.[15]

Another way to examine the role of covariates is to add them sequentially in the framework of equations 9 and 10. Other Table 2 shows how the coefficient on the cutoff dummy changes as we add more and more covariates. Overall, the results show a rather limited role for covariates in determining the size of the coefficient on the cutoff dummy.

6.1.3 Other cutoffs

Is there something unique about 1500 grams or do we observe this pattern along every 100 gram interval? For example, if we observed that children below 1700 grams had lower mortality rates and higher test scores than children slightly above 1700 grams, then we would be concerned that something inherent about getting heaped at 100 gram intervals is driving the results rather than exposure to treatments specific to being less than 1500 grams. In Table 6 we examine every 100 gram cutoff in a similar estimation strategy as in equation 9 and 10. We find that both, mortality and test scores are significantly affected only around the 1500 gram cutoff.

6.2 Heaping concerns

Figure 1 shows a histogram of the distribution of birth weight for a 500 gram window around the VLBW cutoff in 10 gram bins. There are pronounced heaps in this distribution which occurs at the 10, 50 and 100 gram intervals, presumably due to rounding. In particular, in the window of birth weights between 1400g-1600g, approximately 87% of birth

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[15] We recognize that some of the covariates are only barely statistically insignificant. These are, for example, the coefficient on mother's employment status and mother's age. These are likely driven by the heaped point at 1500 grams. Indeed when we recreate this table omitting observations at 100 gram intervals, the coefficients are much smaller while the standard errors stay approximately the same. These tables are available upon request.

weights are rounded to a 10, 34% to 50s and 23% to 100s.[16] Since birth weight is observed at heaps it is natural to worry about whether irregular rounding up (or down) of the data could affect our results. This was pointed out in a recent paper by Barreca et al (2011). In our data, rounding at 10, 50 and 100 gram intervals is significantly correlated with a few demographic characteristics as shown in Table 7.[17] For a subsample of our data we can observe the exact hospital name, and using hospital fixed effects eliminates the correlation between rounding and demographic characteristics. This suggests that while hospitals round, the rounding is not manipulated *within* hospitals. However, selection into hospital type is still a concern in this setting. Barreca et al (2011) suggest two ways, a fixed effects approach and a ”donut” RD to examine whether heaping plays an important role in the results.

6.2.1 Fixed effects for heaping

Table 8 shows the stability of the results when we use fixed effects for heaping at 10, 50 and 100 gram intervals. The results are also quite stable when we simply remove points at 10, 50 and 100 gram bins, even though this decreases sample size by a significant amount. Perhaps the results are less sensitive to heaping in our case (as opposed to the examples in Barreca et al (2011)) since not a lot of data is clustered at the 50 and 100 gram heap.

6.2.2 Donut RD

Barreca et al also recommend a donut RD approach when dealing with heaped data. They suggest removal of points close to the cutoff since the RD is based on estimates as the running variable *approaches* the cutoff from either side. Hence, removing a few points around the cutoff should not significantly alter our results, if the heaped points are not driving everything. In Table 9 we adopt a donut RD approach and find that our results are valid even when we exclude points that 7 grams to either side of 1500 grams. Indeed, this should not be surprising since in Figures 3 and 4, it can be clearly seen that even points at 1490 are quite different from points at 1510. Hence, the heaped point of 1500 grams itself is not driving our results.

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[16] The regressions do not use the end points of 1400 and 1600 as the triangular weights assigned to these points is 0. Hence, not including 1400 and 1600 in the rounding stats makes a difference for the percentage of data observed at heaps. Not including 1400 and 1600 grams, the percentages at 10, 50 and 100 gram heaps are 85%, 22% and 9%. These stats are for births above 32 weeks of gestation.

[17] Graphs that make the same point are in the Appendix.

6.3 Other checks

6.3.1 Polynomial and Bandwidth Selection

Table 10 shows estimates of equation 9 and 10 for a wide variety of bandwidths and polynomials on either side of the 1500 gram cutoff. While the results are largely consistent across different bandwidths for a given polynomial selection, the results across different polynomials for a given bandwidth do tend to differ, specially at smaller bandwidths. We attribute the sensitivity of our results to higher order polynomials to over fitting the data with few data points. To the extent that the results are largely similar for polynomials of up to order 3 and for bandwidths reaching up to 150 grams on either side of 1500, we consider our results to be quite robust to bandwidth and polynomial selection. Moreover, visual inspection of the data and the check suggested by Lee and Lemieux (2010) (inclusion of 10 gram bin dummies and jointly testing that the coefficients on these dummies are zero) indicate that linear trends on either side is a good fit of the data.

6.3.2 Twins and siblings fixed effects

One way to understand the extent to which mother level unobservables might be driving the estimates is to examine children of the same mother. We can do this using twins and siblings that are identified in the data using the unique identifier for the mother. Certainly the demands of the data are rather high - the sample used for identifying the RD within a twin or sibling fixed effects requires one twin (or sibling) on either side of the cutoff, both twins (or siblings) above 32 weeks of gestation and a birth weight difference of no more than 200 grams (*both* have to fall between the range of 1400-1600). With caveats for small samples in place, we estimate mortality regressions (sample is too small for schooling outcomes to estimate this) around the cutoff using twins and siblings. The point here is not to compare these estimates to the overall estimates we showed earlier, but rather to understand how much difference the fixed effect makes. In Table 11 we show that OLS and FE estimates for both twins and siblings are very similar. This suggests that unobserved mother characteristics or propensities to manipulate birth weights say, are not playing an important role in this setting.

7 Other Results

7.1 Parental Investments

As emphasized earlier, interpreting long run impacts of early life events is made difficult by the fact that parents might respond to these shocks. In this instance, we would like to know whether the effects seen for children below 1500 grams are driven by differential parental investment decisions. When the SIMCE is administered a detailed survey is handed out to parents and students. The content of these surveys vary from year to year, but in 2002 they asked a set of detailed parental time investment questions to the parents, and in 2009 they asked a similar set of questions about parental investments to the students. Hence, for a small sample of fourth graders, we have detailed information on time spent by parents in activities such as reading, helping with homework, posing math problems et cetera. Appendix Figures D-2 takes a summary measure of these investments and plots these investments against birth weight as in Figure 3 or 4. There appear to be no differential investments around the cutoff of 1500 grams.[18]

Since we observe the population of school students, we construct several school level variables to understand whether children below the cutoff simply attend very different schools. In Figure D-4, along school characteristics, we find no evidence of different school inputs being chosen for children below 1500 grams.[19] We believe this is suggestive evidence that parental investments do not respond differentially to births below 1500 grams.

7.2 Treatments around 1500 grams

Unfortunately we do not have data on exact treatments received by children above and below 1500 grams. However the Ministry of Health provided us with data on hospital admissions and length of stay for a small subset of the population between 2002-2006.[20] In this data we are only able to identify the number of days spent in the hospital during

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[18] Responses to the questions on investments typically range from 1-4 where 1 is no ”Never” and 4 is ”Very often”. For the graphs presented we simply take the average of these responses. Parental investment data in this setting is discussed in greater detail in Bharadwaj, Eberhard and Neilson (2011). The regression analog of this graph also shows no statistically significant change at the cutoff point. These results available upon request.

[19] We choose school observed as of Grade 4. Changing this to say examining 1st or 2nd grade is not critical to our results.

[20] This data contains about 30% of the births between this time period. The reason for this small match rate is that not many hospitals report to this particular data base, and moreover, many of the reported admissions have missing ID numbers making a match to the vital statistics rather difficult.

the first year of the child's life. In Figure D-5, we find that children above 32 weeks of gestational age, but below 1500 grams spend up approximately 10 extra days in the hospital, and this effect is predominant only in the sample above 32 weeks in gestational age. Since the average length of stay within this birth weight range is around 30 days, being below the cutoff represents a 33% increase in the time spent in the hospital. The extra days in the hospital is likely only a small component of the extra treatments these children receive - as the government documents mentioned in section 3, these children receive many additional treatments. Hence, the results on mortality and school achievement are a function of all these treatments and not *just* of additional time spent in the hospital.

8 Conclusion

In this paper we examined the role of medical interventions early in life and found that they have an impact on neonatal and infant mortality as well as academic achievement later on in life. Children who by virtue of having been born with a birth weight of just less than 1500 grams have higher math scores in school compared to children born just a few grams heavier than 1500 grams. Moreover, children just below the 1500 gram cutoff experience lower mortality rates as a consequence of extra medical attention. While we are unable to fully disentangle the effect of different treatments (the Chilean program provides various treatments), we do make some progress towards this by exploiting the introduction of the universal surfactant program in Chile in 1998. We find suggestive evidence that this program played a key role in further raising test scores and lower mortality.

We are also able to address problems that might arise due to irregular heaping of birth weight at integer intervals. While we do find some evidence of irregular heaping in our data, our results are robust to the correction measures suggested in Barreca et al (2011). In addition, we exploit the idea that all children below 32 weeks of gestational age receive treatments (regardless of birth weight), and in this sample, find no evidence of birth weight cutoffs playing a role in determining outcomes. Moreover, for a rather small subset of the data, we can implement the RD design using a twins or siblings fixed effects. Such a design holds constant observable and unobservable characteristics of the parents. Our key observation here is that employing a fixed effect makes no difference to the estimates in terms of magnitude (and these estimates are statistically significant, even in the small sample). If the magnitudes were to differ substantially, we would worry that unobservable characteristics of parents are an important determinant even around the cutoff. This is further evidence that heaping is less of a concern in this context.

While this paper's main contribution lies in linking early childhood health and later life educational achievement, we are certainly aware that parental investments that react to interventions could play a role here. While addressing this in detail is beyond the scope of this paper, we are certainly cognizant that this might play a role in interpreting our results as the sole consequence of medical treatments. We use a novel survey from Chile to partially address this concern. Using surveys that ask both parents and children about the time involvement of parents in activities such as reading, helping with homework et cetera, we find no evidence that parents of children with birth weight slightly less than 1500 grams invest more than parents of children with birth weight slightly greater than 1500 grams.

Overall, we find an important role for early childhood medical treatments in determining later life outcomes. By examining the impact of treatments on later life test scores, we highlight important spillovers that arise from medical care provided early in life. Moreover, the evidence we provide might help explain why the health-income gradient in adulthood exists: better health in childhood likely improves accumulation and formation of human capital via better cognitive achievement.

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Appendix

A Appendix A - Data Description

Table A-1: Births in 1400g -1600g window in comparison with the population.

	$1400 \leq BW \leq 1600$	All
Mother has College Education	17.1%	16.8%
Mother has High School Education	55.1%	57.7%
Mother has Elementary Education	27.3%	25.1%
None of the above	0.5%	0.4%
Mother is Married	48.2%	50.9%
Mother is Single	51.8%	49.2%
Mother Age at Birth	27.5	26.8
Father Age at Birth	30.5	29.9
Born in Hospital	98.7%	98.7%
Birth Attended by Doctor	54.9%	33.9%
Birth Attended by midwife	45.1%	66.2%

Note: This table shows how the characteristics of mothers of births within the range of 1400g and 1600g compare with the characteristics of mothers in the population of births in general. This data is all collected at the time of birth and is available in the vital statistics. The only noticeable difference between the two groups is that parents are on average a year older and slightly less likely to be married.

We use a database that has matched the administrative records of the population of births in Chile between 1992-2007 to the administrative records on the population of deaths during the same period. This generates a match for virtually all (98%) of official infant deaths over the period we study. In the first year data is available we see a larger proportion of infant and neonatal deaths that are unmatched (18% infant and 4% neonatal deaths missed in 1992) but by 1993, the numbers match above 95% of all deaths occurred. Table A-2 presents how the matched data lines up with the official figures on births and deaths.

Table A-2: Official Death Counts and Matched Births/Deaths

	Total Births	Valid Id Birth	% Missed	Infant M.	B/D	% Missed	Neonatal M.	B/D	% Missed
1992	279098	278,958	0.1%	4209	3,419	18.8%	2254	2,155	4.4%
1993	275916	275,857	0.0%	3792	3,657	3.6%	2007	1,971	1.8%
1994	273766	273,745	0.0%	3454	3,376	2.3%	1971	1,949	1.1%
1995	265932	265,897	0.0%	3107	3,043	2.1%	1695	1,677	1.1%
1996	264793	264,776	0.0%	3095	3,036	1.9%	1743	1,720	1.3%
1997	259959	259,936	0.0%	2732	2,694	1.4%	1569	1,554	1.0%
1998	257105	257,068	0.0%	2793	2,770	0.8%	1614	1,604	0.6%
1999	250674	250,469	0.1%	2654	2,628	1.0%	1547	1,537	0.6%
2000	248893	248,867	0.0%	2336	2,315	0.9%	1467	1,459	0.5%
2001	246116	245,682	0.2%	2159	2,103	2.6%	1290	1,253	2.9%
2002	238981	236,366	1.1%	1964	1,902	3.2%	1249	1,198	4.1%
2003	234486	230,471	1.7%	1935	1,859	3.9%	1212	1,166	3.8%
2004	230352	230,348	0.0%	2034	2,016	0.9%	1305	1,301	0.3%
2005	230831	230,827	0.0%	1911	1,907	0.2%	1254	1,251	0.2%
2006	231383	231,378	0.0%	1839	1,838	0.1%	1249	1,248	0.1%
2007	240569	240,567	0.0%	2009	2,005	0.2%	1356	1,355	0.1%
2008	246581	246,580	0.0%	1948	1,948	0.0%	1369	1,369	0.0%
Average	251496	251,047	0.2%	2587	2,501	2.6%	1538	1,516	1.4%

Note: The first column shows the total amount of official births which is reported by the INE (National Institute of Statistics - Chile) and the Chilean Ministry of Health which provided the source data. The second column shows the amount of births that contained information which allowed the observation to be linked to educational records by the Ministry of Education. Data prior to 1992 is not identifiable and cannot be merged.

The data on school achievement comes from administrative data on the grades and test scores of every student in the country between 2002 and 2009. Use of this data was provided by the Ministry of Education of Chile (MINEDUC) where data from the Health Ministry was merged with schooling data using a unique individual identifier. The database consists of the grades by subject of each student in a given year. We standardize grades for each student at the class room level. In addition, we use the results of a national exam administered to 4th and 8th grade students in Chile called the SIMCE. This test is accompanied by a survey which provides a rich set of demographic characteristics. We refer the interested reader to Bharadwaj, Eberhard, and Neilson (2010) for details on the data used in this paper.

We observe approximately 4 million births between 1992 and 2007, out of which approximately 0.9% (38,000 births) are observed to be below 1500 grams in birth weight. Within the bandwidths we examine in this paper (between 1400 and 1600 grams) we observe approximately 13,000 births. Among these 13,000 births about 7,230 births are for infants who are above 32 weeks of gestation (inclusive). This is the largest sample we observe for the mortality regressions. In general the match between schooling records and vital stats is very accurate. More than 95% of all births within the appropriate age range are matched to their educational records. Table A-3 presents the outcome of the merge between vital stats and educational records taking into account the births that have not survived until schooling age.

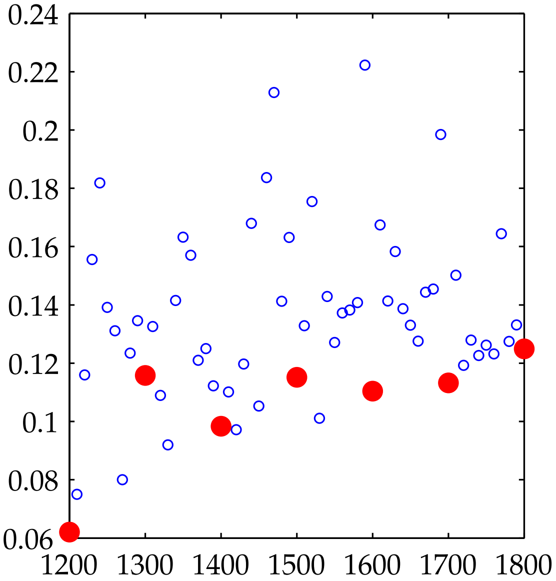
Table A-3: Birth, Death and Schooling Merge

	Dead	Missing	Matched	Missing due to Death	Missing School Records	Total Births
1992	803	241	3,352	18%	5.5%	4,396
1993	714	218	3,158	17%	5.3%	4,090
1994	622	149	3,012	16%	3.9%	3,783
1995	631	173	2,988	17%	4.6%	3,792
1996	577	182	3,128	15%	4.7%	3,887
1997	571	162	3,192	15%	4.1%	3,925
1998	577	183	3,412	14%	4.4%	4,172
1999	526	195	3,466	13%	4.7%	4,187
2000	466	191	3,366	12%	4.7%	4,023
2001	408	156	3,331	10%	4.0%	3,895
2002	357	285	3,236	9%	7.3%	3,878
Average	568	194	3,240	14%	5%	4,003
Total	6,252	2,135	35,641	13%	4%	48,031

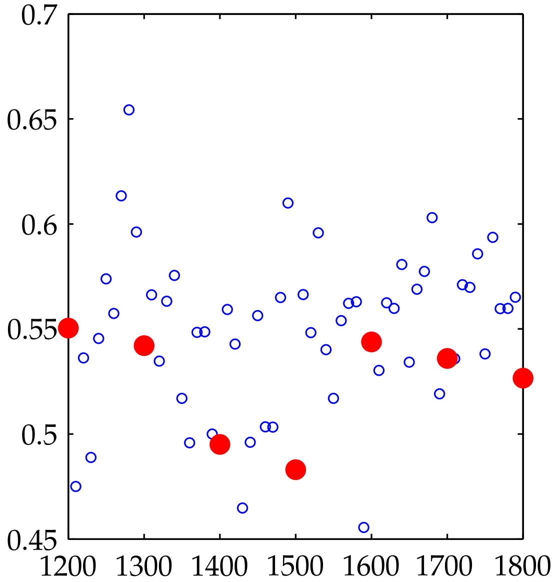
Note: This table shows the amount of births between 1000g and 2000g that are linked to educational records by the Ministry of Education. We see that missing educational records were mainly due to the death of the child, although this went down from 18% to 9% in the decade under study. Births that were not recorded as dead and were not found in the educational database account for an average of 5% of births in the relevant birth weight range.

B Appendix B - Heaping

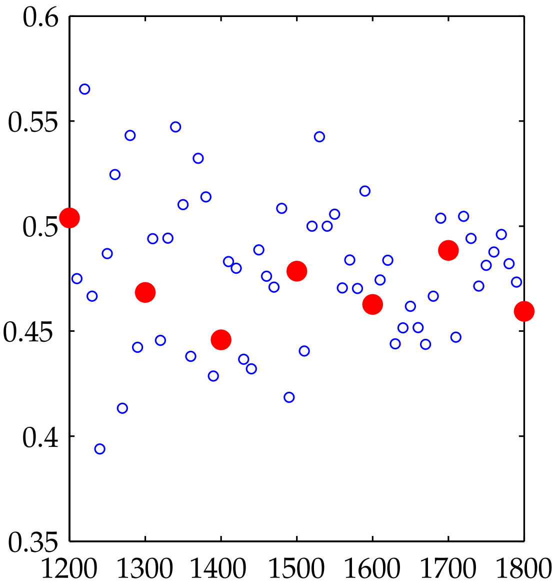
Mother Education - College



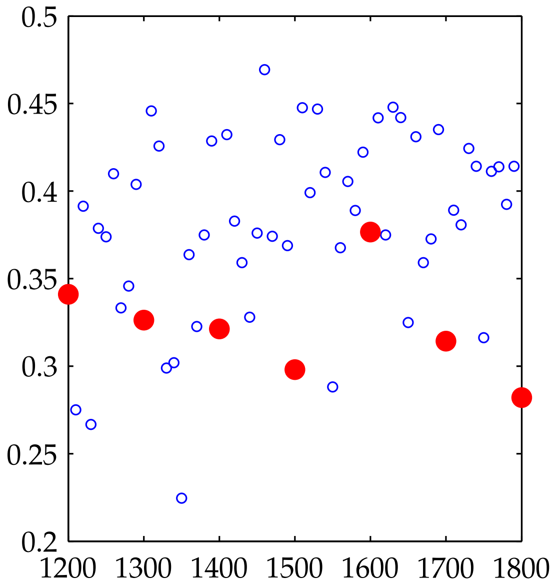
Mother Education - High School



Mother Married

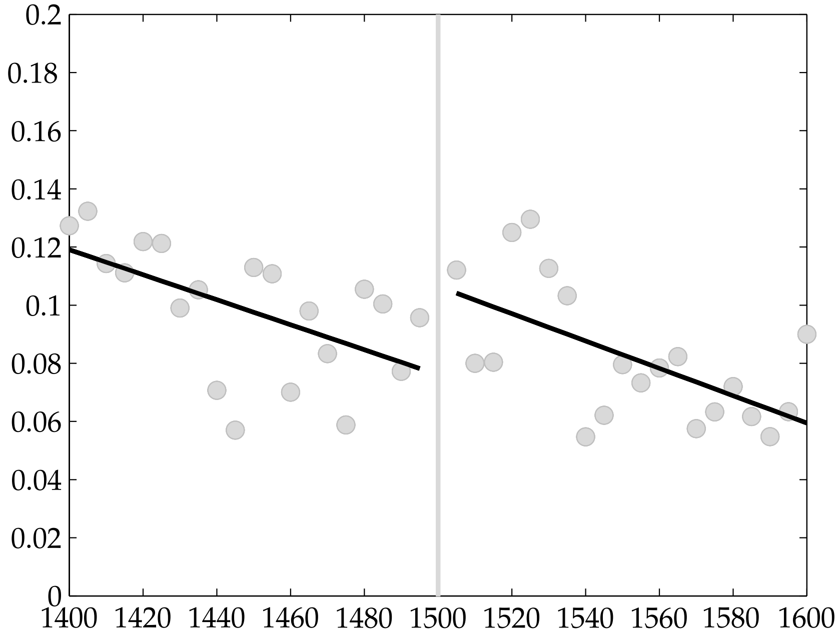


Capital City



C Appendix C - Additional Results

Figure C-1: Neonatal Mortality

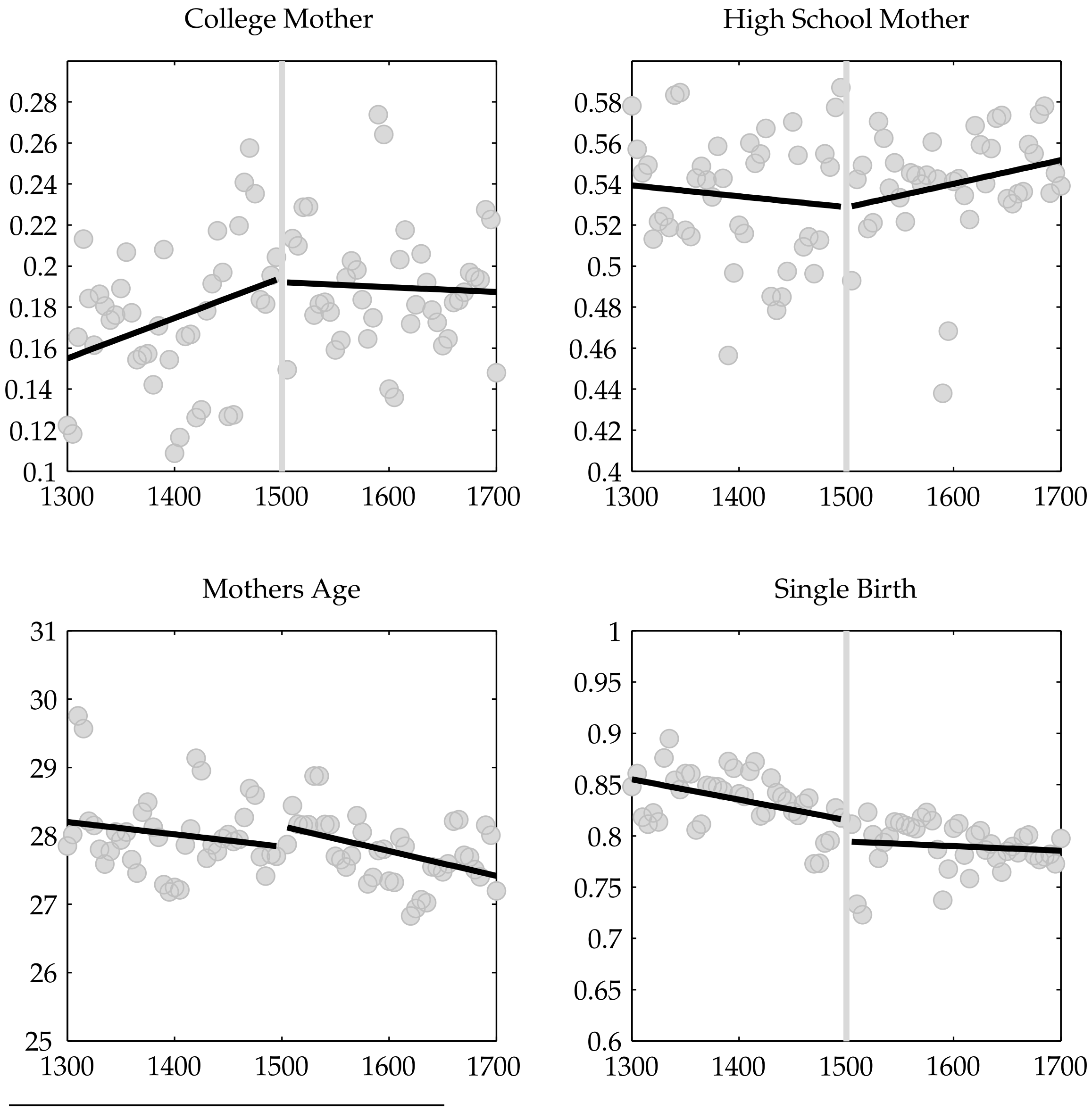


Note: This figure shows average neonatal mortality for 10 gram bins plotted at every 5 gram intervals. This way, the amount of observations in each bin is similar as all bins include a 10 gram multiple which is where most of the birth weight distribution is rounded to. The solid black line is a linear trend fitted to the data in above and below the cutoff.

D Appendix D - Additional Robustness Checks

D.1 Covariates

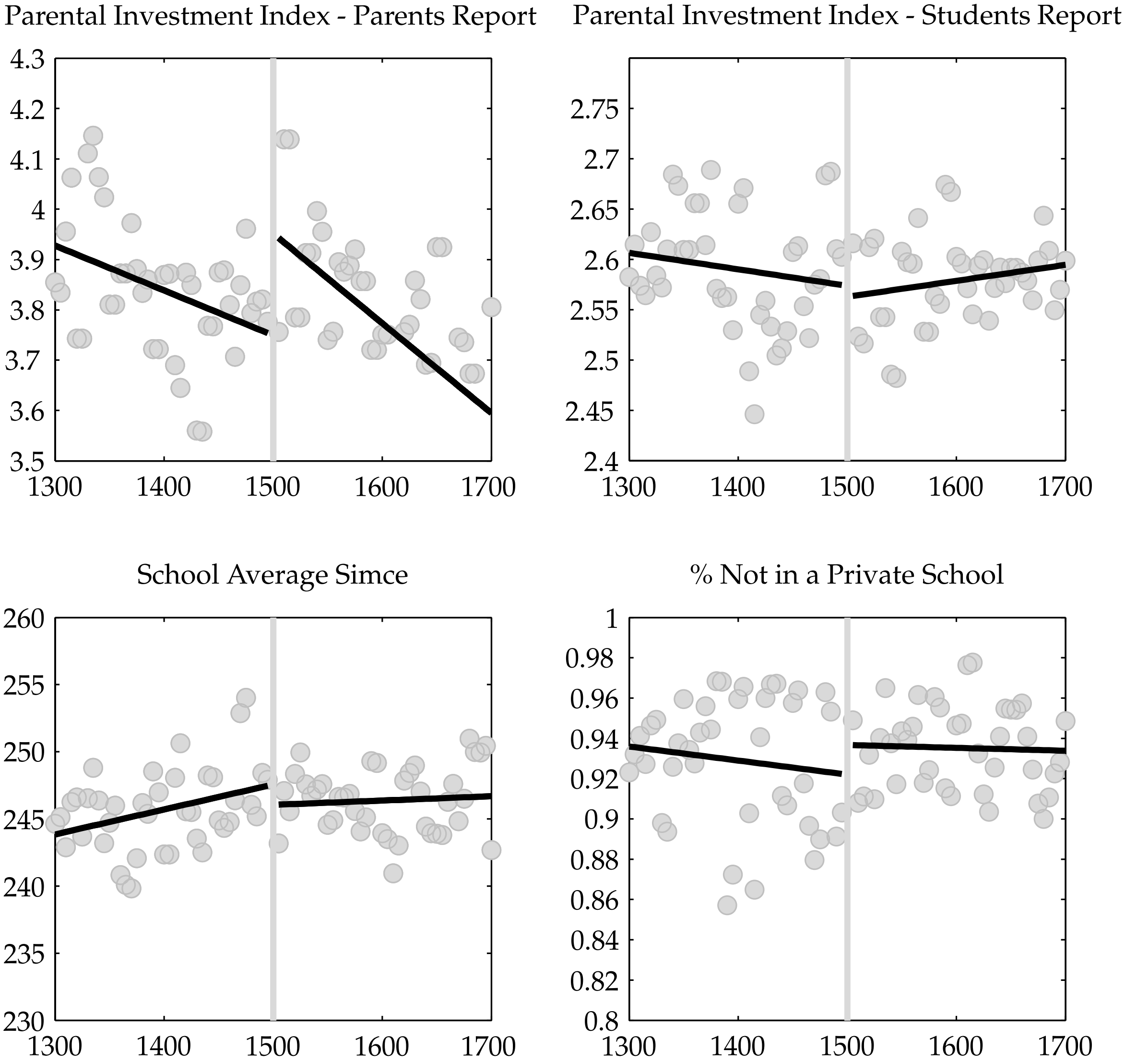
Figure D-2: Covariates across the 1500 threshold



Note: This figure shows the evolution of several covariates of children born around the cutoff of 1500g. Bins are 10 gram wide plotted at every 5 gram interval. This way, the amount of observations in each bin is similar as all bins include a 10 gram multiple which is where most of the birth weight distribution is rounded to. The solid black line is a linear trend fitted to the data in above and below the cutoff.

D.2 Parental Investments

Figure D-3: School Average Test Scores



Parental Investment Index - Parents Report

Parental Investment Index - Students Report

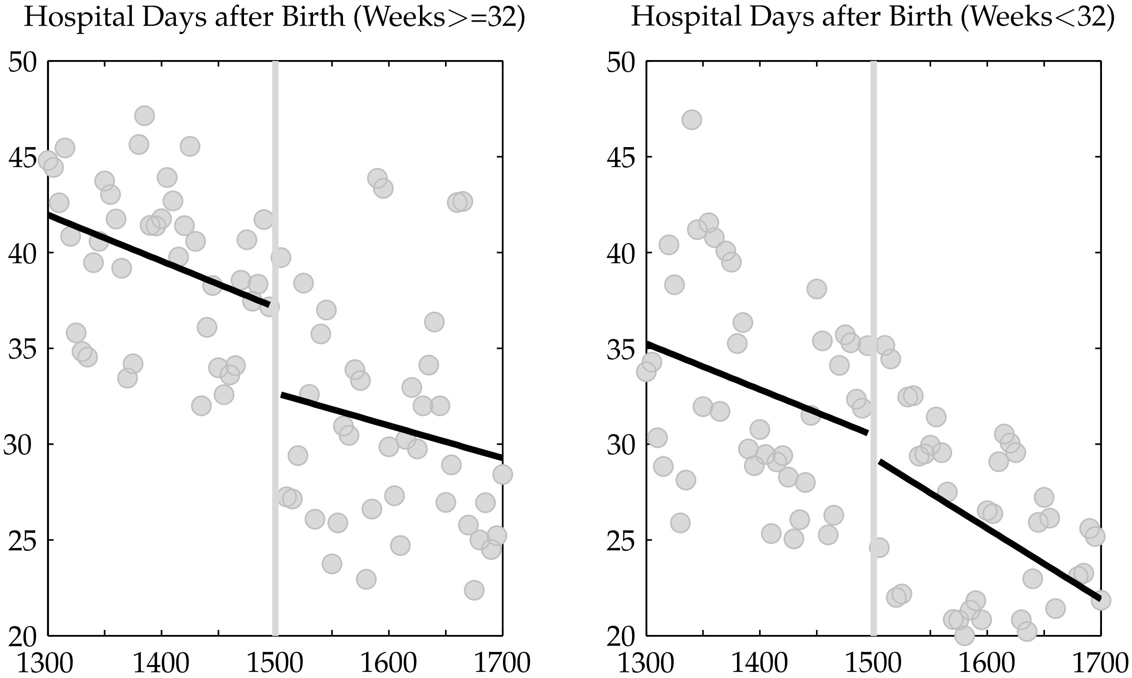
School Average Simce

% Not in a Private School

Note: This figure shows average average school average test scores for 10 gram bins plotted at every 5 gram intervals. This way, the amount of observations in each bin is similar as all bins include a 10 gram multiple which is where most of the birth weight distribution is rounded to. The solid black line is a linear trend fitted to the data in above and below the cutoff.

D.3 Hospital Days at Birth

Figure D-4: Hospital Days



Note: This figure shows the number of days spent in the hospital during the first year of life averaged at 5 gram bins. Data is only provided for a small subsample of the overall data. For details see Section 7 in the text.

Table 1 - Mortality around 1500 grams by Gestational Age

Infant Mortality	All gestational ages	Gestational age >=32 weeks	Gestational age < 32 weeks
Birth Weight<1500	-0.0261	-0.045	-0.0019
	[0.0136]*	[0.0182]**	[0.0198]
(Birth Weight - 1500) X Birth Weight<1500	-0.0001	-0.0001	-0.0001
	[0.0002]	[0.0002]	[0.0003]
(Birth Weight - 1500) X Birth Weight>=1500	-0.0007	-0.001	-0.0002
	[0.0002]***	[0.0003]***	[0.0003]
Constant	0.23	0.1754	0.2927
	[0.0332]***	[0.0396]***	[0.0619]***
Observations	9293	5097	4196

24 Hour Mortality	All gestational ages	Gestational age >=32 weeks	Gestational age < 32 weeks
Birth Weight<1500	-0.0178	-0.0195	-0.0167
	[0.0093]*	[0.0116]*	[0.0114]
(Birth Weight - 1500) X Birth Weight<1500	-0.0002	-0.0001	-0.0003
	[0.0001]**	[0.0001]	[0.0001]***
(Birth Weight - 1500) X Birth Weight>=1500	-0.0003	-0.0005	-0.0001
	[0.0002]*	[0.0002]**	[0.0002]
Constant	0.0461	0.0425	0.0529
	[0.0208]**	[0.0290]	[0.0223]**
Observations	8534	4737	3797

Std errors clustered at the gram level

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth chosen; Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth, 100 gram heap fixed effects. Triangular weights used in all specifications. Births from 1992-2007 in sample.

Table 2 - School performance around 1500 grams by Gestational Age

School scores	Math scores			Language scores		
	All gestational ages	Gestational age >=32 weeks	Gestational age < 32 weeks	All gestational ages	Gestational age >=32 weeks	Gestational age < 32 weeks
Birth Weight<1500	0.073	0.203	-0.081	0.02	0.113	-0.101
	[0.045]	[0.064]***	[0.058]	[0.038]	[0.065]*	[0.051]*
(Birth Weight - 1500) X Birth Weight<1500	0.002	0.003	0	0.001	0.002	0
	[0.001]**	[0.001]***	[0.001]	[0.001]	[0.001]**	[0.001]
(Birth Weight - 1500) X Birth Weight>=1500	0	0.001	-0.001	0	0	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Constant	-0.347	-0.402	-0.3	-0.562	-0.477	-0.715
	[0.099]***	[0.118]***	[0.174]*	[0.095]***	[0.137]***	[0.187]***
Observations	4938	2822	2116	4927	2816	2111

4th Grade SIMCE scores	Math scores			Language scores		
	All gestational ages	Gestational age >=32 weeks	Gestational age < 32 weeks	All gestational ages	Gestational age >=32 weeks	Gestational age < 32 weeks
Birth Weight<1500	-0.034	0.177	-0.299	-0.116	0.105	-0.403
	[0.088]	[0.099]*	[0.132]**	[0.144]	[0.173]	[0.157]**
(Birth Weight - 1500) X Birth Weight<1500	0.002	0.004	-0.001	-0.001	0.001	-0.003
	[0.001]	[0.002]**	[0.002]	[0.002]	[0.003]	[0.003]
(Birth Weight - 1500) X Birth Weight>=1500	-0.001	-0.001	-0.001	-0.001	0	-0.001
	[0.001]	[0.001]	[0.002]	[0.001]	[0.002]	[0.002]
Constant	-0.443	-0.435	-0.377	-0.79	-0.893	-0.632
	[0.193]**	[0.250]*	[0.282]	[0.235]***	[0.382]**	[0.236]***
Observations	1774	1047	727	1778	1054	724

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth chosen; Covariates:Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth, 100 gram heap fixed effects. Triangular weights used in all specifications. Births from 1992-2002 in sample. SIMCE scores are only available for the years 2002 and 2005-2008 and only for grade 4.

Table 3 - Counterfactuals using non survivors of infancy

	Only survivors	Percentile of test score assigned to non-survivors above 1500 grams					
		Median	55th	60th	65th	75th	80th
Birth Weight<1500	0.203	0.187	0.187	0.187	0.17	0.123	0.089
	[0.064]***	[0.067]***	[0.067]***	[0.066]***	[0.070]**	[0.071]*	[0.072]
(Birth Weight - 1500) X Birth Weight<1500	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***
(Birth Weight - 1500) X Birth Weight>=1500	0.001	0.001	0.001	0.001	0.001	0.001	0
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Constant	-0.402	-0.342	-0.342	-0.342	-0.326	-0.274	-0.233
	[0.118]***	[0.114]***	[0.114]***	[0.115]***	[0.119]***	[0.120]**	[0.122]*
Observations	2822	3165	3165	3165	3165	3165	3165

Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth. Infants above 32 weeks (inclusive of 32 weeks) of gestational age used in analysis. Triangular weights used in all specifications. Non survivors are assigned the mentioned percentile score based on their birth weight. Births from 1992-2002 in sample.

Table 4 - Impact of National Surfactant Program on test scores around 1500 grams

	School outcomes		Mortality Outcomes	
Mortality esitmates (1992-2005 data only)	Math scores	Language scores	Infant Mortality	24 Hr Mortality
Post 1998 * Birth Weight cutoff	0.179	0.256	-0.057	-0.022
	[0.096]*	[0.117]**	[0.025]**	[0.031]
Post 1998 (1=1998 and later, 0 otherwise)	-0.273	-0.3	-0.05	-0.02
	[0.069]***	[0.076]***	[0.010]***	[0.017]
Birth Weight<1500	0.131	0.021	-0.015	-0.017
	[0.057]**	[0.067]	[0.028]	[0.022]
Constant	-0.434	-0.54	0.188	0.065
	[0.116]***	[0.119]***	[0.042]***	[0.038]*
Observations	2822	2816	3797	3507

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth around each cutoff chosen; Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth, 100 gram heap fixed effects. Infants above 32 weeks (inclusive of 32 weeks) of gestational age used in analysis. Triangular weights used in all specifications. Births from 1992-2002 in sample for schooling outcomes. Births from 1992-2003 in mortality sample. Linear trends on either side of the cutoff, and trends interacted with post are also used in all specifications.

Table 5 - Other covariates examined at 1500 grams

Covariates	Mother's Age	Mother attended college	Mother attended high school	Mother married	Birth Mother Employed	Non twin birth
Birth Weight<1500	-0.5561	0.0432	0.0392	0.0134	0.0591	0.0056
	[0.3896]	[0.0320]	[0.0258]	[0.0217]	[0.0361]	[0.0236]
(Birth Weight - 1500) X Birth Weight<1500	-0.0094	0.0008	0.0005	0	0.001	-0.0005
	[0.0063]	[0.0006]	[0.0005]	[0.0004]	[0.0004]**	[0.0003]
(Birth Weight - 1500) X Birth Weight>=1500	-0.004	0.0003	0.0004	-0.0002	0.0003	0.0002
	[0.0046]	[0.0004]	[0.0003]	[0.0002]	[0.0006]	[0.0003]
Constant	28.7138	0.1676	0.584	0.6032	0.2961	0.8549
	[0.7660]***	[0.0264]***	[0.0671]***	[0.0469]***	[0.0382]***	[0.0316]***
Observations	5616	5682	5682	5266	5677	5682

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth chosen; Covariates: Region of birth. Triangualar weights used in each specification. This table uses data from 1992-2007. Infants of gestational age >= 32 weeks in sample.

Table 6 - Examining Cutoffs between 1100-3000 grams

Math scores				*Infant Mortality*			
Cutofff point	Coefficient on cutoff	Cutofff point	Coefficient on cutoff	Cutofff point	Coefficient on cutoff	Cutofff point	Coefficient on cutoff
1100	-0.406	2100	0.022	1100	0.011	2100	0.007
	[0.195]**		[0.025]		[0.017]		[0.005]
1200	-0.091	2200	-0.014	1200	0.063	2200	0.006
	[0.150]		[0.016]		[0.045]		[0.003]
1300	-0.082	2300	0.025	1300	0	2300	0.002
	[0.107]		[0.032]		[0.000]		[0.003]
1400	0.05	2400	0.003	1400	0.015	2400	-0.004
	[0.059]		[0.014]		[0.024]		[0.002]**
1500	0.157	2500	0.016	1500	-0.044	2500	-0.002
	[0.062]**		[0.012]		[0.018]**		[0.002]
1600	-0.011	2600	0	1600	-0.009	2600	-0.003
	[0.044]		[0.016]		[0.010]		[0.001]**
1700	-0.017	2700	-0.026	1700	0.007	2700	-0.001
	[0.053]		[0.010]**		[0.014]		[0.001]
1800	0.005	2800	0.001	1800	-0.009	2800	0
	[0.058]		[0.011]		[0.012]		[0.001]
1900	-0.033	2900	-0.002	1900	0.005	2900	-0.001
	[0.026]		[0.011]		[0.005]		[0.001]
2000	-0.002	3000	-0.016	2000	-0.002	3000	0
	[0.021]		[0.006]***		[0.006]		[0.001]

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth around each cutoff chosen; Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth, 100 gram heap fixed effects. Infants above 32 weeks (inclusive of 32 weeks) of gestational age used in analysis. Triangular weights used in all specifications. School sample uses births from 1992-2002, mortality sample uses births from 1992-2007.

Table 7 - Heaping and Demographic Characteristics

Complete sample: 1992-2007	Heaps observed (in grams)			Heaps observed (in grams) - with municipality of birth fixed effects			Heaps observed (in grams) - with hospital fixed effects		
Birth weight ranges from 1200-1800 grams	10	50	100	10	50	100	10	50	100
Mother attended high school	-0.0015	-0.018	-0.0193	-0.001	-0.0125	-0.0141	-0.011	-0.006	0.004
	[0.0039]	[0.0052]***	[0.0052]***	[0.0038]	[0.0047]***	[0.0043]***	[0.008]	[0.010]	[0.007]
Mother attended college	-0.09	-0.0519	-0.0496	-0.0629	-0.0335	-0.035	-0.009	0.003	0.001
	[0.0106]***	[0.0128]***	[0.0139]***	[0.0091]***	[0.0109]***	[0.0111]***	[0.012]	[0.014]	[0.014]
Mother's Age	-0.0005	-0.0001	-0.0005	-0.0003	0.0001	-0.0004	0	0.001	0
	[0.0003]*	[0.0003]	[0.0003]*	[0.0003]	[0.0003]	[0.0002]*	[0.000]	[0.001]	[0.000]
Father's Age	0.0001	-0.0002	-0.0001	0.0001	-0.0002	0	0	0	0
	[0.0002]	[0.0002]	[0.0002]	[0.0001]	[0.0002]	[0.0001]	[0.000]	[0.000]	[0.000]
Married	0.0166	0.0171	0.015	0.0134	0.016	0.0136	-0.006	0.008	0.005
	[0.0040]***	[0.0052]***	[0.0047]***	[0.0039]***	[0.0049]***	[0.0048]***	[0.007]	[0.010]	[0.006]
Single Birth	0.014	0.0064	0.0026	0.0057	0.0023	-0.0004	-0.01	-0.001	-0.002
	[0.0054]***	[0.0091]	[0.0074]	[0.0052]	[0.0088]	[0.0074]	[0.009]	[0.012]	[0.010]
Mother Employed	-0.0165	-0.0065	0.0051	-0.009	0.0001	0.0096	0.012	-0.002	0.003
	[0.0050]***	[0.0064]	[0.0051]	[0.0047]*	[0.0061]	[0.0052]*	[0.009]	[0.009]	[0.007]
Constant	1.0546	0.5186	0.3295	0.959	0.4266	0.2904	0.875	0.292	0.224
	[0.0143]***	[0.0928]***	[0.0995]***	[0.0125]***	[0.0787]***	[0.0845]***	[0.137]***	[0.211]	[0.140]
Observations	33224	33224	33224	33224	33224	33224	10140	10140	10140

Std errors clustered at the gram level

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: Infants of all gestational ages in sample. Region of birth fixed effects in all regressions unless municipality of birth fixed effects are used. This table uses data from 1992-2007. Hospital identifiers only available after 2002.

Table 8 - Robustness to Heaping

Math scores	Fixed effects for heaps			Removing points at heaps		
	10	50	100	10	50	100
Birth Weight<1500	0.164	0.173	0.203	0.622	0.202	0.203
	[0.048]***	[0.055]***	[0.064]***	[0.276]**	[0.061]***	[0.066]***
(Birth Weight - 1500) X Birth Weight<1500	0.003	0.003	0.003	0.004	0.003	0.003
	[0.001]***	[0.001]***	[0.001]***	[0.004]	[0.001]***	[0.001]***
(Birth Weight - 1500) X Birth Weight>=1500	0	0.001	0.001	0.004	0.001	0.001
	[0.001]	[0.001]	[0.001]	[0.004]	[0.001]*	[0.001]
Constant	-0.34	-0.364	-0.402	0.147	-0.351	-0.441
	[0.138]**	[0.113]***	[0.118]***	[0.605]	[0.143]**	[0.135]***
Observations	2822	2822	2822	263	2135	2552

Infant Mortality	Fixed effects for heaps			Removing data at heaps		
	10	50	100	10	50	100
Birth Weight<1500	-0.0279	-0.0317	-0.045	-0.071	-0.0443	-0.0431
	[0.0145]*	[0.0150]**	[0.0182]**	[0.0371]*	[0.0184]**	[0.0186]**
(Birth Weight - 1500) X Birth Weight<1500	-0.0001	-0.0001	-0.0001	-0.0003	-0.0001	-0.0001
	[0.0002]	[0.0002]	[0.0002]	[0.0006]	[0.0002]	[0.0002]
(Birth Weight - 1500) X Birth Weight>=1500	-0.0006	-0.0007	-0.001	-0.0017	-0.0011	-0.001
	[0.0002]***	[0.0002]***	[0.0003]***	[0.0006]***	[0.0003]***	[0.0003]***
Constant	0.1756	0.1593	0.1754	0.1221	0.2158	0.1849
	[0.0467]***	[0.0464]***	[0.0396]***	[0.1130]	[0.0418]***	[0.0473]***
Observations	5097	5097	5097	765	3963	4636

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth. Infants above 32 weeks (inclusive of 32 weeks) of gestational age used in analysis. Triangular weights used in all specifications. Births from 1992-2002 in test scores sample, births from 1992-2007 in mortality sample.

Table 9 - Donut RD Design

	Size of donut around 1500 grams							
Math scores	0	1	2	3	4	5	6	7
Birth Weight<1500	0.203	0.203	0.203	0.203	0.2	0.203	0.203	0.202
	[0.066]***	[0.066]***	[0.066]***	[0.066]***	[0.066]***	[0.068]***	[0.068]***	[0.068]***
(Birth Weight - 1500) X Birth Weight<1500	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***	[0.001]***
(Birth Weight - 1500) X Birth Weight>=1500	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Constant	-0.441	-0.441	-0.441	-0.441	-0.436	-0.436	-0.436	-0.44
	[0.135]***	[0.135]***	[0.135]***	[0.135]***	[0.135]***	[0.135]***	[0.135]***	[0.135]***
Observations	2552	2552	2552	2552	2551	2543	2543	2542

	Size of donut around 1500 grams							
Infant Mortality	0	1	2	3	4	5	6	7
Birth Weight<1500	-0.0431	-0.0431	-0.0436	-0.0436	-0.044	-0.0417	-0.0411	-0.0388
	[0.0186]**	[0.0186]**	[0.0188]**	[0.0188]**	[0.0193]**	[0.0194]**	[0.0195]**	[0.0193]**
(Birth Weight - 1500) X Birth Weight<1500	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0003]	[0.0003]	[0.0003]
(Birth Weight - 1500) X Birth Weight>=1500	-0.001	-0.001	-0.001	-0.001	-0.001	-0.0009	-0.0009	-0.0009
	[0.0003]***	[0.0003]***	[0.0003]***	[0.0003]***	[0.0003]***	[0.0003]***	[0.0003]***	[0.0003]***
Constant	0.1849	0.1849	0.1761	0.1769	0.1772	0.1755	0.1758	0.1778
	[0.0473]***	[0.0473]***	[0.0472]***	[0.0472]***	[0.0472]***	[0.0473]***	[0.0473]***	[0.0478]***
Observations	4636	4636	4627	4624	4608	4577	4571	4567

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth. Infants above 32 weeks (inclusive of 32 weeks) of gestational age used in analysis. Triangular weights used in all specifications.

Table 10: Sensitivity to Bandwidth and Polynomial Selection in Test Score Regressions

Average over 8 years of test scores

Bandwidth	50	60	70	80	90	100	110	120	130	140	150
Polynomial											
1	0.227	0.18	0.172	0.178	0.173	0.165	0.143	0.128	0.115	0.111	0.104
	[0.054]***	[0.053]***	[0.053]***	[0.051]***	[0.049]***	[0.047]***	[0.045]***	[0.044]***	[0.041]***	[0.040]***	[0.039]***
2	0.397	0.335	0.268	0.2	0.199	0.204	0.218	0.224	0.217	0.195	0.189
	[0.106]***	[0.074]***	[0.067]***	[0.067]***	[0.061]***	[0.058]***	[0.056]***	[0.056]***	[0.055]***	[0.055]***	[0.054]***
3	0.383	0.467	0.47	0.422	0.305	0.245	0.203	0.19	0.213	0.248	0.237
	[0.289]	[0.200]**	[0.135]***	[0.106]***	[0.094]***	[0.089]***	[0.081]**	[0.075]**	[0.067]***	[0.064]***	[0.064]***
Observations	1314	1761	2018	2276	2593	2822	3466	3688	4075	4359	4666

Infant Mortality

Bandwidth	50	60	70	80	90	100	110	120	130	140	150
Polynomial											
1	-0.044	-0.039	-0.037	-0.039	-0.043	-0.044	-0.031	-0.029	-0.028	-0.027	-0.027
	[0.031]	[0.024]	[0.021]*	[0.020]**	[0.019]**	[0.018]**	[0.017]*	[0.016]*	[0.015]*	[0.015]*	[0.014]*
2	-0.001	-0.032	-0.036	-0.032	-0.027	-0.032	-0.023	-0.018	-0.017	-0.017	-0.017
	[0.054]	[0.050]	[0.045]	[0.039]	[0.033]	[0.030]	[0.020]	[0.017]	[0.016]	[0.016]	[0.016]
3	-0.063	0.012	-0.009	-0.026	-0.036	-0.026	-0.007	0.005	0.012	0.012	0.007
	[0.072]	[0.070]	[0.062]	[0.059]	[0.056]	[0.052]	[0.035]	[0.026]	[0.020]	[0.018]	[0.017]
Observations	2470	3222	3693	4147	4696	5106	6145	6578	7214	7718	8261

Notes: 100 gram bandwidth chosen; Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth, 100 gram heap fixed effects. Infants with gestation age greater than or equal to 32 weeks in sample. Triangular weights used in each specification. Top panel uses birth from 1992-2002, while lower panel uses births from 1992-2007.

Table 11 - Infant Mortality around 1500 grams with Twins and Sibling Fixed Effects

	Twins Sample			Siblings Sample		
Mortality esitmates	Fixed effects: Gestational Age<32 weeks	OLS: Gestational age >= 32 weeks	Fixed Effects: Gestational age >= 32 weeks	Fixed effects: Gestational Age<32 weeks	OLS: Gestational age >= 32 weeks	Fixed Effects: Gestational age >= 32 weeks
Birth Weight<1500	0.185	-0.218	-0.307	0.093	-0.166	-0.163
	[0.121]	[0.072]***	[0.153]*	[0.513]	[0.053]***	[0.093]*
(Birth Weight - 1500) X Birth Weight<1500	0	-0.002	-0.003	-0.001	-0.001	-0.002
	[0.002]	[0.001]**	[0.002]*	[0.007]	[0.001]***	[0.001]*
(Birth Weight - 1500) X Birth Weight>=1500	0.001	-0.001	-0.001	0.001	-0.001	0
	[0.001]	[0.001]**	[0.001]*	[0.004]	[0.000]**	[0.000]
Constant	0.23	0.151	-0.038	0.22	0.098	-0.08
	[0.148]	[0.054]***	[0.115]	[0.486]	[0.043]**	[0.155]
Observations	733	164	164	5121	247	247
Pairs						

Std errors clustered at the gram level

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth chosen. Births from 1992-2007 in sample. Covariates in all regressions are 100 gram heap and sex dummies.

Other Table 1 - Test score effect evaluated by grade level

Grade in school	1	2	3	4	5	6
Birth Weight<1500	0.211	0.084	0.259	0.093	0.067	0.039
	[0.070]***	[0.061]	[0.089]***	[0.084]	[0.100]	[0.089]
(Birth Weight - 1500) X Birth Weight<1500	0.004	0	0.003	0.002	0.002	0.002
	[0.001]***	[0.001]	[0.001]**	[0.002]	[0.002]	[0.001]**
(Birth Weight - 1500) X Birth Weight>=1500	0.002	0.001	0.002	0	0	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Constant	-0.265	0.418	0.108	1.294	0.561	0.867
	[0.328]	[0.592]	[0.472]	[0.360]***	[0.225]**	[0.273]***
Observations	1834	1914	1874	1836	1789	1569

Std errors clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Covariates: Sex, Region of birth, Mother's age, Mother's education, Mother's marital status, Type of birth service, Year of birth, and age at grade. Infants above 32 weeks (inclusive of 32 weeks) of gestational age used in analysis. Triangular weights used in all specifications. Births from 1992-2002 in sample.

Other Table 2: Discontinuity at 1500 grams Sequentially adding covariates

100 gram band width around 1500, coefficient	1	2	3	4	5
Average Math Scores in School	0.142	0.197	0.165	0.203	0.182
	[0.045]***	[0.048]***	[0.047]***	[0.064]***	[0.060]***
Math SIMCE Score in 4th Grade	0.248	0.309	0.201	0.187	0.163
	[0.092]***	[0.110]***	[0.086]**	[0.097]*	[0.130]
Infant Mortality	-0.0415	-0.0433	-0.0427	-0.045	-0.0516
	[0.0168]**	[0.0119]***	[0.0165]**	[0.0182]**	[0.0197]***
Neonatal Mortality	-0.0291	-0.0287	-0.0281	-0.0238	-0.0277
	[0.0166]*	[0.0132]**	[0.0202]	[0.0218]	[0.0186]
24 Hour Mortality	-0.0241	-0.024	-0.0256	-0.0195	-0.0195
	[0.0113]**	[0.0076]***	[0.0108]**	[0.0116]*	[0.0106]*
Covariates included		1+ triangular weights	2+100 gram heap fixed effect	3+Mother's age, education, marital status; type of birth service, region of birth and year of birth	4+Municipality of birth fixed effect

Standard errors in brackets, clustered at the gram level
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: 100 gram bandwidth chosen; infants with gestational age equal to or greater than 32 weeks in sample. All specifications are similar to those in Table 1. Only the coefficient on cutoff dummy reported. Sample sizes are different across different specifications and outcome variables.