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Birth Weight, Neonatal Intensive Care Units, and Infant Mortality: Evidence from Macrosomic Babies*

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September 1, 2017

Abstract

Using a regression discontinuity design, this study estimates the effect of extra medical care on the short-run health of babies born at the high end of the birth weight distribution. Consistent with the notion that neonatal treatment decisions are guided by a rule of thumb when assigning medical care to macrosomic newborns, we find evidence of a large discontinuous jump in the likelihood of being admitted to a neonatal intensive care unit (NICU) as the 5000-gram cutoff is crossed from below. The resulting plausibly exogenous variation in medical care in the vicinity of the 5000-gram cutoff identifies the health effect of additional medical care. Parametric and non-parametric regressions reveal that being born above the 5000-gram cutoff increases the probability of NICU admission by about 30% and decreases the risk of infant mortality by about 130% relative to sample means below the 5000-gram cutoff. The importance of the substantial health gains associated with extra medical care in the macrosomic patient population is likely to grow over time since maternal obesity, a major risk factor for macrosomia, is on the rise.

JEL Classification: I12, I14.

Keywords: medical intervention, birth weight, mortality.

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1 Introduction

This study uses plausibly exogenous variation in neonatal care induced by rule-of-thumb health treatment decisions made around a birth weight cutoff at the upper end of the birth weight distribution to identify the impact of extra medical care on the risk of infant mortality. Prior work has mainly focused on underdeveloped newborns, characterized by a low birth weight (LBW). Medical research has shown that being born with a LBW increases the risk of developmental problems, which increases as birth weight decreases (Abernethy et al., 2002, Hack et al., 1995). Economic studies have shown that health treatments received by very LBW children are effective in reducing the risk of infant mortality and improving subsequent health and academic achievement (Almond et al., 2010, Bharadwaj et al., 2013, Breining et al., 2015, Cutler and Meara, 2000).[1] These findings, however, apply only to the lower end of the birth weight distribution. The returns to additional medical care may vary along the birth weight distribution. Investigation of this issue is important since recent natality data indicate that, while the percent of LBW newborns is on the decline, the percent of high birth weight (HBW) or *macrosomic* newborns is on the rise (see Figure 1).[2] Maternal obesity has been shown to raise the risk of having a macrosomic baby, so the increasing rate of macrosomia is partially driven by rising maternal obesity rates (Leddy et al., 2008),[3] and may continue to rise given the projected increase in obesity prevalence over the next 2 decades (Finkelstein et al., 2012).

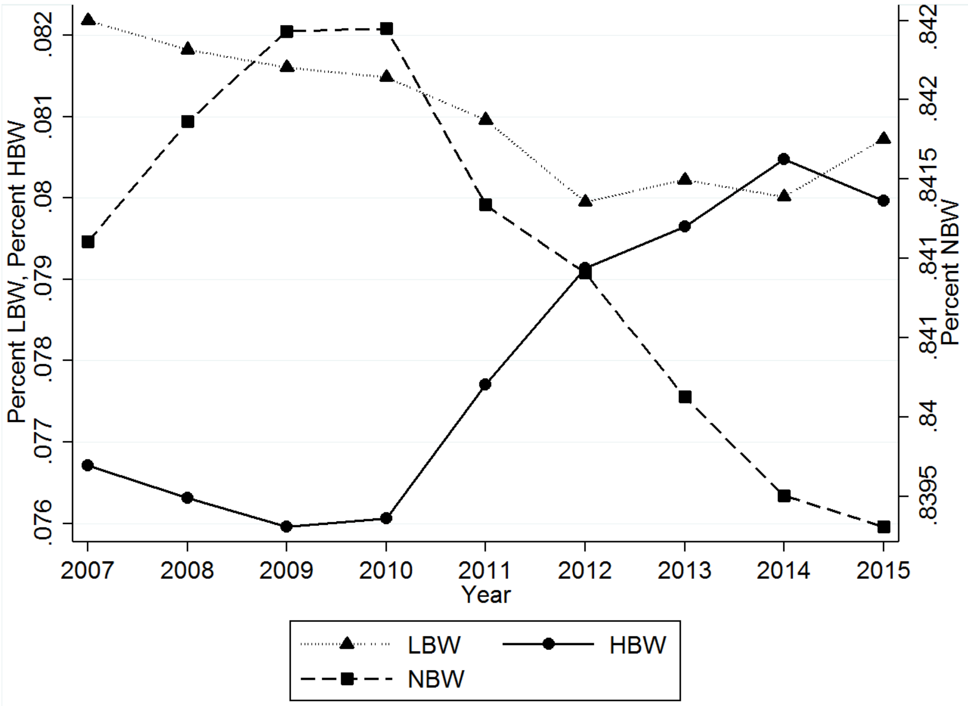
In contrast to the lower end of the birth weight distribution, the health risks associated with macrosomia increase as birth weight increases. For example, medical studies have shown that the risk of birth trauma, birth asphyxia, and infant mortality all grow as birth weight increases along the macrosomic part of the birth weight distribution (Boulet et al., 2003, Oral et al., 2001, Vidarsdottir et al., 2011, Zhang et al., 2008). Notably, infant morbidity and mortality risks rise sharply when birth weight goes beyond 4500 grams and are most serious above 5000 grams (Chatfield, 2001, Gottlieb and Galan, 2007).

[1] In related research, Daysal et al. (2016), using a regression discontinuity design in which medical treatments are assigned based on gestational age, found that there were no health benefits associated with providing additional treatments to low-risk newborns.

[2] *Macrosomia* implies fetal growth beyond a specific birth weight. The diagnostic threshold for macrosomia has been variously defined, but is typically defined as a birth weight of at least 4000 grams, regardless of gestational age (Chatfield, 2001).

[3] The CDC estimated that, in 2014, about 25% of women who gave birth were obese before becoming pregnant and pre-pregnancy obesity prevalence increased for the majority of reporting U.S. states between 2011 and 2014 (Branum et al., 2016). Interestingly, this rise in pre-pregnancy obesity coincides with the rise in the rate of macrosomia shown in Figure 1.

Figure 1
Percent of Newborns, by Birth Weight Category



Notes: These data are drawn from the CDC Wonder System. Low birth weight (LBW) is defined as a birth weight below 2500 grams; normal birth weight (NBW) is defined as a birth weight of at least 2500 grams but less than 4000 grams; and high birth weight (HBW) or macrosomia is defined as a birth weight of at least 4000 grams.

Building on prior research showing that a rule of thumb is often used for assigning medical care to very LBW children (Almond et al., 2010, Bharadwaj et al., 2013, Breining et al., 2015, Cutler and Meara, 2000), we exploit a comparable rule of thumb in the assignment of medical care along the macrosomic segment of the birth weight distribution to estimate the health returns to providing additional medical care to macrosomic babies. In particular, in our first-stage analysis, we establish that the response of a health treatment by hospital staff is discontinuously heterogeneous across a macrosomic point of the birth weight distribution. We then show that there is also a discontinuity in infant mortality risk at the same threshold which, taken together, suggests that the plausibly exogenous heterogeneity in medical care across the macrosomic cutoff generates the heterogeneity in the risk of infant mortality. Following Almond et al. (2010) and Bharadwaj et al. (2013), the underlying assumption in our analysis is that newborns born within a small birth-weight window around the macrosomic cutoff are identical except for the extra medical care that slightly heavier macrosomic newborns receive as a result of rule-of-thumb treatment decisions that are triggered when newborns weigh-in above the macrosomic cutoff. A comparison of macrosomic newborns slightly below and above the macrosomic cutoff lowers the risk that confounding factors play a role in explaining heterogeneity in treatment and mortality risk in the vicinity of the macrosomic cutoff, and this risk decreases as the birth-weight window narrows.

The increasing share of obese mothers in the population makes it relevant and timely to estimate the health returns to providing extra medical care to macrosomic babies since rising maternal obesity rates will likely put upward pressure on the share of babies that is born with macrosomia in the future.[4] To achieve this objective, our analysis makes use of data from the Birth Cohort Linked Birth-Infant Death Files, provided by the US National Center for Health Statistics, which, starting in 2007, has collected newly available information on the health treatments received by newborns. In a regression discontinuity framework, we analyze whether being born above a macrosomic cutoff affects the probability of receiving health treatments in the delivery hospital and the risk of infant mortality through the first year of life. Parametric regressions reveal that, around the 5000-gram or extremely HBW cutoff, the probability of admission to a neonatal intensive care unit (NICU) is around 2 percentage points higher for extremly HBW infants, which is large relative to the mean NICU admission rate among newborns born below 5000 grams (7.6%). Consistent with the extra medical care received by newborns above the 5000-gram cutoff, we find that being born with an extremely HBW lowers infant mortality risk by around 0.1 percentage points, which is also large relative to the mean mortality rate among newborns born below 5000 grams (0.1%). Non-parametric regressions, which use a sample of macrosomic newborns who are born within a window of less than 80 grams (about 3 ounces) around the 5000-gram cutoff, reveal similar estimated effects relative to sample means. Our results are by and large robust to a wide variety of robustness and sensitivity checks, including checks related to heaping of observations at the cutoff, bandwidth selection, and functional-form assumptions. We do not find similar discontinuities at other macrosomic cutoffs, which is consistent with the idea that the sensitivity of rule-of-thumb health treatment assignment may grow with the expected morbidity and mortality risks associated with heavier macrosomic babies. These results are consistent

[4]As is the case for LBW (Almond et al., 2010, Cutler and Meara, 2000), the healthcare costs associated with macrosomia are substantial. For example, Lenoir-Wijnkoop et al. (2005) noted that, while the routine cost associated with a normal pregnancy and vaginal delivery was about $7,790 (in $2009) in the U.S., a case involving a mother afflicted with gestational diabetes mellitus came at an average total cost of about $15,593. About $3,799 or almost 25% of this total cost came from the costs associated with neonatal complications for a macrosomic newborn. This figure amounts to almost 50% of the cost associated with a normal pregnancy and vaginal delivery.

with prior work showing that, at the lower end of the birth weight distribution, there are health treatment discontinuities at the relatively riskier 1500-gram cutoff (very LBW) but not at the 2500-gram cutoff (LBW) (Almond et al., 2010).

The rest of the paper is organized as follows. Section 2 provides a detailed description of the data used in the analysis. Section 3 discusses the graphical evidence of the discontinuities in health treatment assignment and infant mortality risk along the macrosomic segment of the birth weight distribution. Section 4 outlines our empirical strategy. Section 5 discusses our main results and the results from a battery of robustness and sensitivity checks. Finally, Section 6 concludes.

2 Data

Data for this study were obtained from the 2007-2010 Birth Cohort Linked Birth-Infant Death Files.[5] These files are compiled by the US National Center for Health Statistics, based on information provided by US states under the Vital Statistics Cooperative Program. Our data set includes information from the birth certificate and, if the infant died before the first birthday, information from the death certificate. The birth certificate provides information on the child's and the mother's demographic characteristics, the child's health conditions at birth, information on maternal behavior during pregnancy, and the method of delivery. Critical for our analysis, starting in 2007, the birth certificate includes information on the health treatments received by the newborn in the delivery hospital where treatment decisions are guided by observed circumstances of the newborn immediately after birth. In particular, we observe if the infant was admitted to a NICU or received treatments to address respiratory distress, such as ventilation or surfactant, as might be the case if there is evidence of birth asphyxia (Gallacher et al., 2016, Wirbelauer and Speer, 2009).[6] The death certificate, if applicable, reports the reason and the age of death. We keep only children who died of natural causes[7] and construct three measures of infant mortality, according to whether the child died within 28 days, 6 months, or 1

[5]This data set contains information on deaths to all infants born in the same calendar year for which the death certificate can be linked to a birth certificate. Starting in 2007, all US states collect information on health treatments received by newborns, and, for this reason, we focus on the latest available years of data, i.e., from 2007 to 2010.

[6]We cannot observe if, after delivery, the child was discharged from the hospital and transferred to another clinic where he or she received additional health treatments.

[7]Deaths from non-natural causes (e.g. accident, homicide, etc.) represent only 0.1% of all deaths in our sample.

year after birth.

At present, there is not a general consensus on the definition of fetal macrosomia. Authors have defined it as a birth weight of either at least 4000 grams, at least 4500 grams, or at least 5000 grams, regardless of gestational age. We focus our analysis on the high end of the macrosomic segment of the birth weight distribution, i.e., around the 1500-gram indicator, which is where, as we discuss in more detail below, health treatment assignment varies discontinuously across a diagnostic threshold consistent with rule-of-thumb decision-making. Evidence that rule-of-thumb treatment assignment occurs among heavier macrosomic newborns accords well with the 2016 *Clinical Management Guidelines for Obstetrician-Gynecologists*, in which The American College of Obstetricians and Gynecologists (ACOG) recognize a continuum of risk and divide macrosomia into 3 categories: (1) birth weight of 4000-4499 with increased risk of labor abnormalities and newborn complications; (2) birth weight of 4500-4999 grams with additional risk of maternal and newborn morbidity; and (3) birth weight of 5000 grams or greater with additional risk of stillbirth and neonatal mortality (ACOG, 2016). The most dire health risks are associated with newborns born above 5000 grams, which suggests that practitioners are likely to be most sensitive at the 5000-gram cutoff when considering health treatments for macrosomic babies and, indeed, this is what we observe in the data. In the prior ACOG guidelines (issued November 2000), which is perhaps more relevant for our study period (2007-2010), the ACOG supported the use of the 4500-gram threshold for diagnosis of macrosomia because the risk of infant morbidity rises sharply beyond this birth weight (Chatfield, 2001, Gottlieb and Galan, 2007). Thus, in Section 5, we also investigate whether there are health treatment discontinuities at other macrosomic cutoffs below and above the 5000-gram cutoff.

In our analysis, when we employ a manual bandwidth, we keep observations within 340 grams from the cutoff, corresponding to 12 ounces or three-quarters of a pound. Studies that have focused on the 1500-gram cutoff used bandwidths that range from 85 grams to 200 grams, which is between 5.7% to 13.3% of the cutoff value, respectively (Almond et al., 2010, Bharadwaj et al., 2013, Breining et al., 2015). The manual bandwidth we use in the analysis is wider, given the smaller sample size around the larger cutoff value under investigation here; however, similar to the aforementioned papers, our bandwidth is small relative to the cutoff value (6.8%).[8].

We restrict our analysis to singleton births, which represent about 99 percent of our sample of newborns. Due to the non-trivial number of observations with missing information on the mother's educational level and the mother's smoking behavior during pregnancy, we keep observations for which information on these variables is missing, by assigning the median value to the missing information and by including two additional indicators for missing information in the regressions.[9]

Table 1 reports the descriptive statistics for all the variables used in the analysis. The first row indicates that about 17% of observations lie to the right of the 5000-gram cutoff. As expected, the most frequently used treatments for these macrosomic newborns are NICU admission and cesarean section. Given the focus on the high end of the birth weight distribution, mortality rates are very low in this sample.

3 Treatments to and mortality of extremely HBW newborns: descriptive evidence

It is important to note that health treatments occur at different phases of the delivery, and are differently related to the observation of birth weight by health practitioners. More precisely, while the risk of macrosomia can be estimated during pregnancy, by observing some characteristics of the mother or the fetus through an ultrasound, the exact birth weight of the baby (and whether it is just above or below a particular macrosomic threshold) can be observed only after the delivery has taken place.[10] This means that doctors may opt for a cesarean section if they foresee issues associated with a vaginal birth, but this choice does not depend on the actual birth weight of the child.

By contrast, the other treatments (NICU, ventilation, and surfactant) represent choices that hospital staff make after the delivery has taken place, and, hence, after the actual weight at birth of the child has been observed. The analysis of a variety of treatments allows us to understand if there are different treatment responses to extremely HBW babies

[8]Also, as we show below, our results and conclusions are similar when the bandwidth is decreased in both parametric and non-parametric regression frameworks.

[9]The median value is 0 for both the indicators for a mother having a college degree or more and for the mother having smoked during pregnancy.

[10]Prenatal estimation of fetal weight has been shown to be very inaccurate, especially in the case of macrosomic fetuses (Colman et al., 2006, Dudley, 2005, Hoopmann et al., 2010).

Table 1
Descriptive statistics for the sample around the 5000-gram threshold

	Mean	SD	Min	Max
Birth weight > 5000 grams	0.169	0.375	0	1
NICU	0.087	0.282	0	1
C-section	0.563	0.496	0	1
Ventilation	0.053	0.223	0	1
Surfactant	0.002	0.042	0	1
28-day mortality	0.001	0.033	0	1
6-month mortality	0.001	0.038	0	1
1-year mortality	0.002	0.040	0	1
Mother's age	29.530	5.783	13	50
Mother has a college degree or more	0.359	0.480	0	1
Mother's education missing	0.007	0.081	0	1
White non-hispanic	0.611	0.488	0	1
Hispanic	0.276	0.447	0	1
Black/Other race non-hispanic	0.113	0.317	0	1
Married mother	0.697	0.459	0	1
Male	0.686	0.464	0	1
N. Prenatal visits > 11	0.654	0.476	0	1
Term birth	0.776	0.417	0	1
Mother smoked in pregnancy	0.043	0.202	0	1
Smoking info missing	0.130	0.336	0	1
Mother had previous c-section	0.210	0.407	0	1
Mother weight gain	17.521	8.215	0	44.453
N. Observations	45203			

Notes: Authors' calculations using the linked birth/death certificates data, 2007-2010. Sample of US births with birth weight between 4660 and 5340 grams.

and represents the first-stage analysis. Since differential treatment in the hospital may result in differences in subsequent health status, we complement this first-stage analysis by also examining the likelihood of infant mortality around the same cutoff at 28 days, 6 months, and 1 year.

We now proceed with descriptive evidence of discontinuities in health treatment assignment and infant mortality risk around the 5000-gram threshold. Figures 2 and 3 show that there is a discontinuity in NICU admission and infant mortality around the 5000-gram threshold. Specifically, Figure 2 shows that there is a sizable discontinuous jump in the probability of being admitted to a NICU at the 5000-gram threshold: the probability of being admitted to a NICU increases from 12% for newborns whose birth weight is just below 5000 grams to 16% for those with a birth weight just above 5000 grams.

The graphs do not appear to show any other meaningful discontinuities in health treatments around the 5000-gram cutoff, including cesarean section, which is more frequently used than the respiratory treatments (ventilation and surfactant) for this category of newborns. As shown in Table 1, cesarean section is a common delivery method adopted for macrosomic babies in our sample. The use of cesarean section seems to be continuous across the 5000-gram threshold, which is consistent with the idea that, while 5000 grams is certainly above the threshold recommended for diagnosis of macrosomia, the delivery-method response is a function of a noisy estimate of fetal weight. Similarly, use of the respiratory treatments also appears to be continuous across the 5000-gram threshold.

In the case of the mortality outcomes, there is a sizable discontinuous drop in mortality risk as birth weight crosses the 5000-gram cutoff from below. This is consistent with the sizable discontinuous rise in NICU admission as the 5000-gram cutoff is crossed from below. That is, the extra medical care that babies born above 5000 grams receive in a NICU may translate into a lower risk of mortality. The drop in mortality risk is largest in the first 28 days, which suggests that any health benefit associated with additional medical care received in a NICU may taper over time.

Finally, the figures also show that the sample size differs significantly below and above the 5000-gram threshold. As shown in Table 1, over 80% of observations are below 5000 grams. As we discuss in greater detail below, in addition to the parametric regressions we discuss in the next section, we also estimate non-parametric regressions that use a more similar number of observations on either side of the cutoff.

4 Empirical strategy

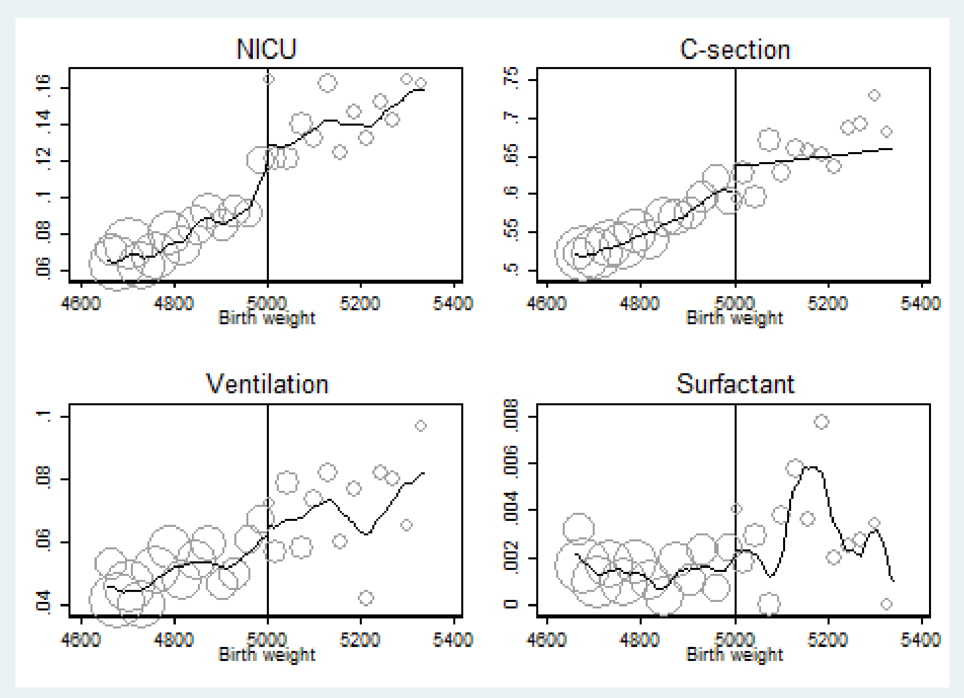
In order to identify the effect of having a birth weight above a certain macrosomic threshold on both health treatments and infant mortality, we adopt a regression discontinuity (RD) design. We start by specifying the following parametric regression:

$$y_i = \beta + \gamma I[bw_i > \bar{bw}] + f(bw_i - \bar{bw}) + X_i\delta + \epsilon_i \tag{1}$$

where γ identifies the effect of being above a macrosomic cutoff, i.e. $\bar{bw} = 5000$. The running variable bw_i is centered at the cutoff point, so that the intercept represents the value of the outcome at the cutoff. $f(bw_i - \bar{bw})$ is a polynomial in the distance from the cutoff; in the analysis, we control for separate linear trends in the running variable on each side of the 5000-gram cutoff, thus allowing the slopes to differ on either side of

Figure 2

Treatments around the 5000-gram threshold

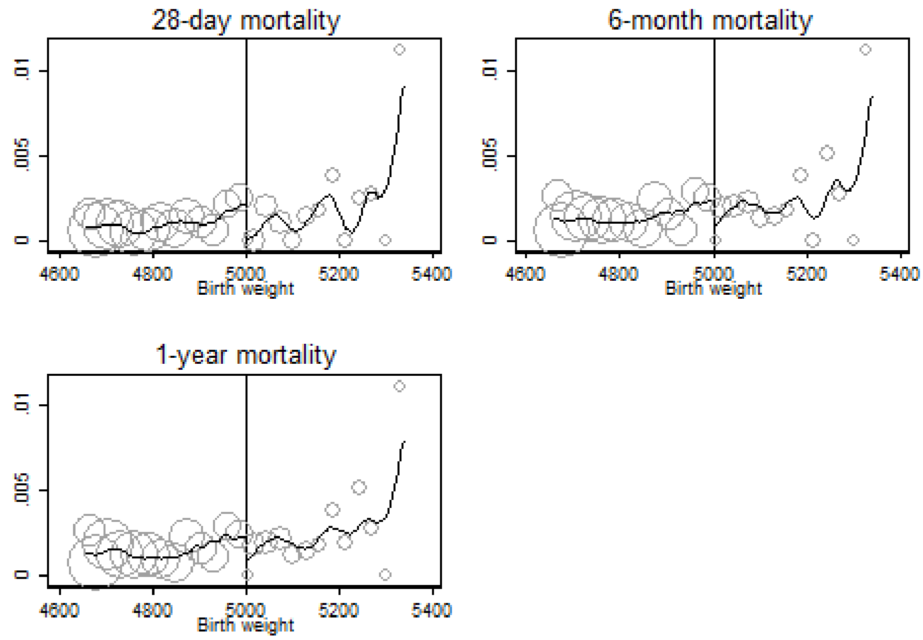


Notes: The circles represent the average of the treatment indicators inside 28-gram bins, weighted by the number of observations within each bin, and plotted as a function of the distance of a child's birth weight (in grams) from the 5000-gram threshold. The bold lines are local linear regressions of the underlying individual observations, with a triangular kernel. Sample of US births with birth weight between 4660 and 5340 grams. $N = 45203$.

the cutoff.[11] The vector X represents a set of control variables including demographic characteristics of the mother (age and its square, college education, whether the mother has the information on education missing, race/ethnicity, and marital status), as well as characteristics of the pregnancy and of a previous delivery (the number of prenatal visits, whether the baby was born after the 39th week of gestation, whether the mother smoked during pregnancy, and whether information on smoking was missing, whether the mother had a previous cesarean section in a previous birth, and her weight gain during pregnancy). Equation 1 is estimated by weighted OLS, using the sample of newborns within a birth-weight window of 340 grams, which corresponds to 12 ounces or three-quarters of a pound. All the parametric regressions use a triangular weight, which is decreasing in the distance from the cutoff, so observations near the cutoff receive higher weight than do observations far from the cutoff. Following Lee and Card (2008), given that our running variable, birth weight, is discretized due to rounding, our standard errors

[11] As we discuss in Section 5, we also estimate parametric regressions in which we control for separate quadratic trends in the running variable on each side of the cutoff. Following Gelman and Imbens (2017), we report results from parametric regressions with linear and quadratic polynomials (but not higher-order polynomials) and complement this analysis with results from non-parametric regressions.

Figure 3
Mortality around the 5000-gram threshold



Notes: The circles represent the average of the mortality indicators inside 28-gram bins, weighted by the number of observations within each bin, and plotted as a function of the distance of a child's birth weight (in grams) from the 5000-gram threshold. The bold lines are local linear regressions of the underlying individual observations, with a triangular kernel. Sample of US births with birth weight between 4660 and 5340 grams. $N = 45203$.

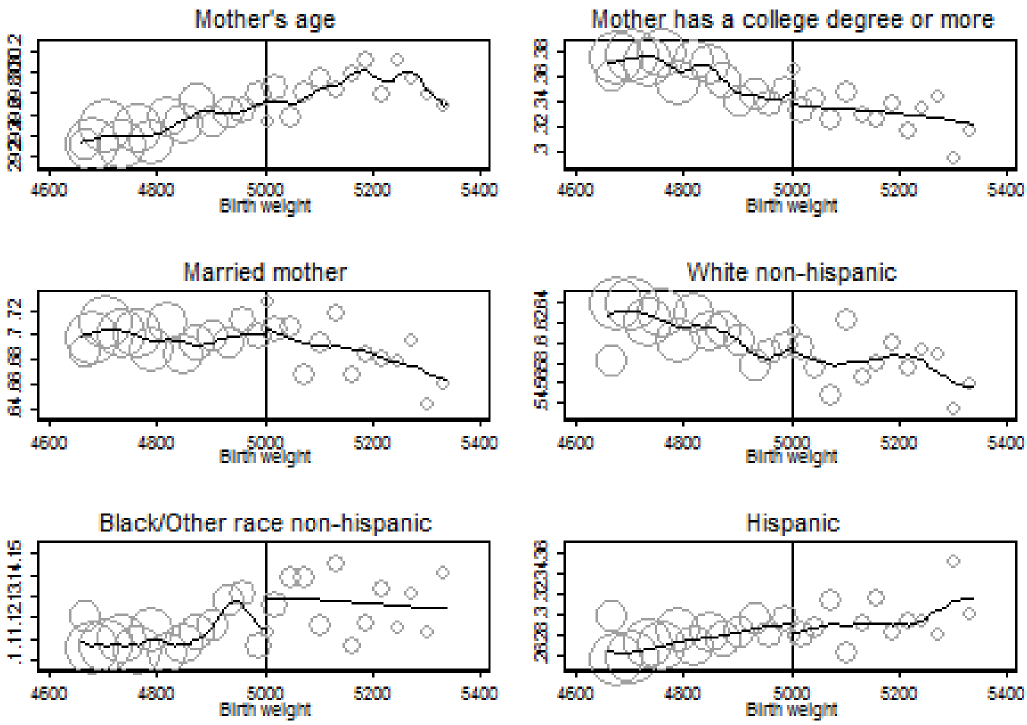
are clustered at the gram level of birth weight in all specifications.

We consider a variety of outcome variables, which are represented by y_i in equation 1. For the analysis of health treatments, we focus on (i) whether the child was admitted to a NICU, (ii) whether the birth occurred through cesarean section, (iii) whether the child received assisted ventilation, and (iv) whether the child was treated with surfactant. We also consider mortality at 28 days, 6 months, and 1 year. The analysis of the various health treatments represents our first-stage, which helps understanding the channels that drive any effect on infant mortality.

The identification of the effects of having a birth weight above 5000 grams on the outcomes of interest relies on three factors. First, as is satisfied in our setting with birth weight, there must be a continuous measure of health risk that is observed by health practitioners. Second, identification relies on the assumption that a diagnostic threshold generates a discontinuity in extra medical care. The fulfillment of this assumption is demonstrated in Figure 2, which shows that NICU admission rates behave in a discontinuous fashion around the 5000-gram cutoff. Finally, identification relies on the assumption that other observable pre-birth characteristics of the infant and the mother are continuous across the threshold (Imbens and Lemieux, 2008, Lee and Lemieux, 2010).[12] Figures 4 and 5 report the distribution of demographic and clinical factors around the 5000-gram threshold, and do not show any evidence of meaningful discontinuities across the 5000-gram cutoff. In a formal test of the continuity of covariates, we estimated local linear regressions around the 5000-gram threshold and did not detect any statistically significant changes at the cutoff.[13]

Figure 4

Continuity of covariates around the 5000-gram threshold: mother's characteristics.



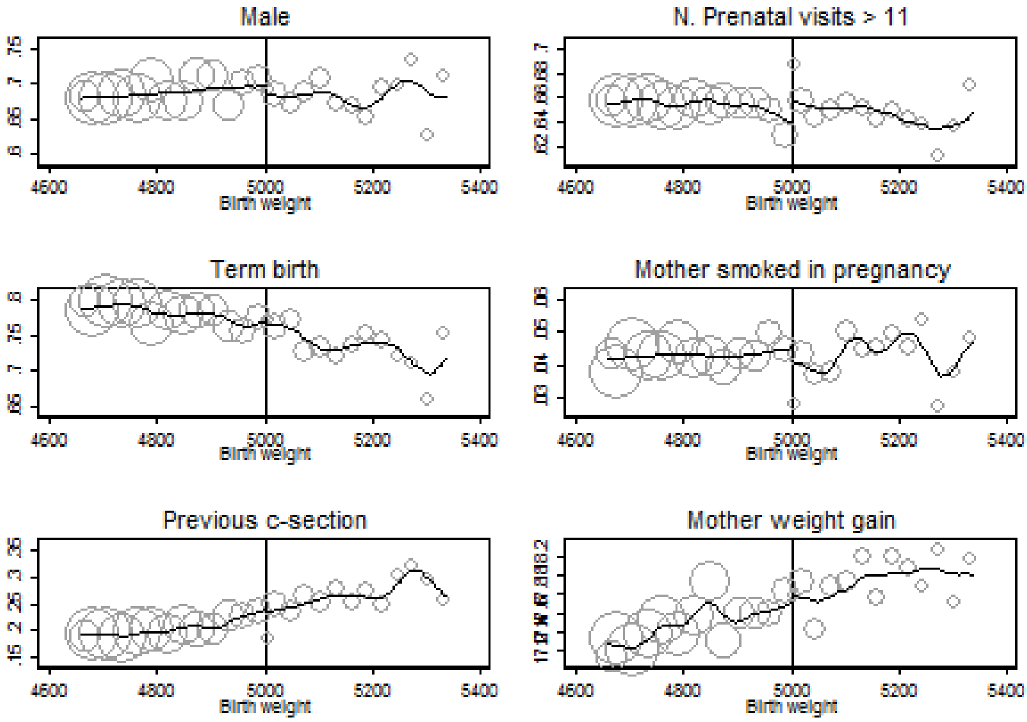
Notes: The circles represent the average of the pre-birth characteristics inside 28-gram bins, weighted by the number of observations within each bin, and plotted as a function of the distance of a child's birth weight (in grams) from the 5000-gram threshold. The bold lines are local linear regressions of the underlying individual observations, with a triangular kernel. Sample of US births with birth weight between 4660 and 5340 grams. $N = 45203$.

Previous work has thrown light on the importance of exploring whether there is heaping of observations at the cutoff (Barreca et al., 2016). Figure 6 reports the frequency of births in the sample centered at the 5000-gram cutoff. We observe peaks at gram equivalents of ounce intervals, but we do not observe systematically different heaps around the

[12] In Appendix Table A.1, we also show that the wide variety of pre-birth characteristics used in the analysis explains only a small fraction of the variation in an extremely HBW outcome.

[13] The p-values associated with the extremely HBW outcome indicator in these regressions ranged from 0.145 and 0.921. Detailed results are available upon request.

Figure 5
Continuity of covariates around the 5000-gram threshold: birth and pregnancy characteristics.

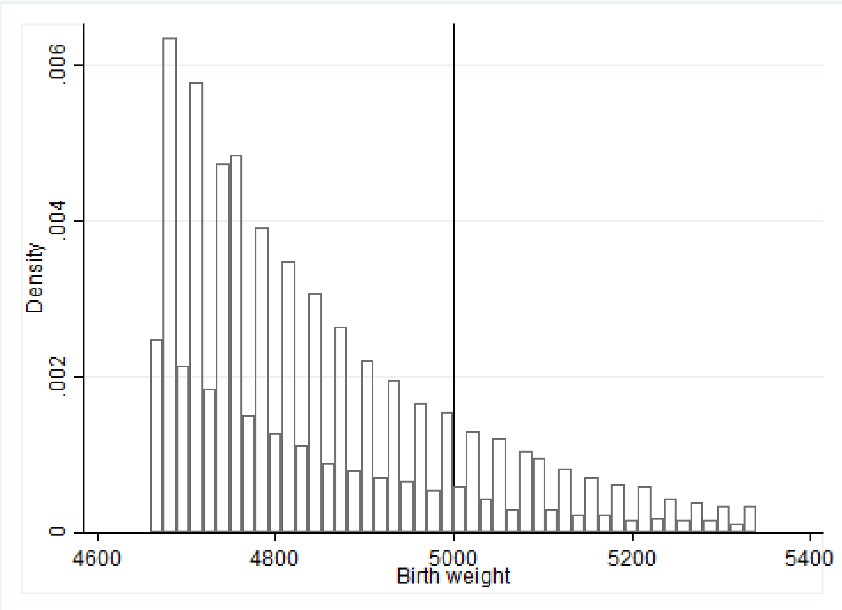


Notes: The circles represent the average of the pre-birth characteristics inside 28-gram bins, weighted by the number of observations within each bin, and plotted as a function of the distance of a child's birth weight (in grams) from the 5000-gram threshold. The bold lines are local linear regressions of the underlying individual observations, with a triangular kernel. Sample of US births with birth weight between 4660 and 5340 grams. $N = 45203$.

5000-gram threshold of interest. This is consistent with women being unable to predict birth weight in advance of birth with the accuracy necessary to move their newborn (via birth timing) from just above or below the threshold. However, as Barreca et al. (2011) point out, the results can be sensitive to the exclusion of observations in the immediate vicinity of the threshold, and, for this reason, in a robustness analysis, we also drop observations at the threshold and within one gram from the threshold.

As noted above, we start with a 340-gram bandwidth, but we test the sensitivity of the results by using a smaller bandwidth in a series of robustness analyses. It is important to note that by estimating a parametric RD specification, we have prioritized precision over bias because of the relatively small number of observations in the 5000-gram sample. In order to reduce the risk that any bias introduced in the parametric analysis associated with choice of functional form drives our results, in a complementary analysis shown in Section 5, we also carry out non-parametric estimation of the effects of interest by using an optimally computed bandwidth, which is much smaller than the manual one used in the baseline analysis. This approach may result in less bias in the estimates, but also results in less statistical power due to the smaller sample size.

Figure 6
Frequency of births by gram around the 5000-gram threshold



Notes: Authors' calculations using linked birth/death certificates data, 2007-2010. Sample of US births with birth weight between 4660 and 5340 grams without missing information in the variables listed in Table 1. $N = 45203$.

5 Results

The results from the baseline analysis, where we consider observations in a bandwidth of 340 grams from the 5000-gram threshold, are presented in Table 2, Panel A. All the regressions include linear trends in the running variable, which are allowed to differ on either side of the cutoff, control for the pre-birth characteristics listed in Table 1, and use a triangular weight that prioritizes observations near the cutoff. Column (1) reports the estimated effect of being extremely HBW on the probability of being admitted to a NICU. Confirming the discontinuity that we observe in Figure 2, we find a positive and statistically significant effect: the probability of being admitted to a NICU is 2.15 percentage points higher for extremely HBW newborns; considering that the average NICU admission rate below the 5000-gram cutoff is about 7.6%, this effect is large, as it corresponds to almost three-tenths of the average. Columns (2)-(4) show that there is no other statistically significant effect of being an extremely HBW newborn on the other health treatments, as was suggested by the descriptive evidence presented in Section 3.

The infant mortality results reported in Table 2, Panel A, Columns (5)-(7), are in line with those for NICU. We find a very large negative effect of being above 5000 grams on infant mortality, which is consistent with a positive effect of being above 5000 grams on NICU admission. We estimate that being born with an extremly HBW lowers the risk of 28-day mortality by about 0.13 percentage points. This is a reduction of about 130% relative to the very low mean mortality rate (0.1%) below the 5000-gram cutoff.[14] Estimates of the 180- and 365-day mortality risk effects are smaller and not statistically significant at conventional levels.

We check the robustness of our results along many dimensions. Panel B and C of Table 2 report the results from the parametric regressions, where we keep the baseline bandwidth of 340 grams but drop the observations at the cutoff (*Donut* specification, in Panel B) or within one gram from the cutoff (*Donut1* specification, in Panel C). These specifications allow us to eliminate any biases induced by the heaping of observations at the cutoff, or by any manipulation of the running variable. As before, we find a positive and statistically significant effect on NICU admission, and a negative and statistically significant effect on 28-day mortality, but no significant effects on the other treatments or longer-run mortality; moreover, the coefficients for NICU and 28-day mortality are very similar to the baseline.[15]

As we mention in Section 2, our baseline bandwidth of 340 grams is slightly larger than the bandwidth adopted in studies focusing on the 1500-gram cutoff (Almond et al., 2010, Bharadwaj et al., 2013) because of the very small sample size around the extremely HBW cutoff. Panels D, E, and F of Table 2 show the results from estimations using a smaller bandwidth of 227 grams, corresponding to about 8 ounces or half a pound, instead of three-quarters of a pound. The results are not sensitive to a decrease in the size of the bandwidth, neither when we keep all observations (Panel D) nor when we apply *Donut* specifications (Panel E and F). We only observe a small reduction in statistical power for the NICU estimates (Column 1), as one might expect due to the smaller sample size.

[14] Using US data, Almond et al. (2010) found that 28-day mortality risk falls by about 1 percentage point when birth weight crosses the 1500-gram cutoff from above, which is about 25% relative to the mean 28-day mortality rate (3.8%) among newborns with a birth weight above 1500 grams. Our results indicate that there are substantial health returns to extra medical care in the right tail of the birth weight distribution as well.

[15] Following Barreca et al. (2011), we also examined whether our results are sensitive to heaping by including 50-gram heap fixed effects in the regressions. The results are very similar to the *Donut* and *Donut1* regression results shown in Table 2 and are available upon request.

Table 2
Parametric regressions for treatments and mortality outcomes around the 5000-gram threshold. Baseline and robustness checks.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	NICU	C-section	Surfactant	Ventilation	28-day mortality	180-day mortality	365-day mortality
Panel A: Baseline BW 340g							
Birthweight > 5000*g*	0.0215***	0.0015	0.0002	0.0053	-0.0013**	-0.0008	-0.0009
	(0.0075)	(0.0164)	(0.0010)	(0.0092)	(0.0006)	(0.0009)	(0.0009)
N	45203	45203	45203	45203	45203	45203	45203
Panel B: BW 340g & Donut							
Birthweight > 5000*g*	0.0235***	0.0017	0.0002	0.0055	-0.0014**	-0.0008	-0.001
	(0.0073)	(0.0165)	(0.0010)	(0.0093)	(0.0006)	(0.0009)	(0.0009)
N	45096	45096	45096	45096	45096	45096	45096
Panel C: BW 340g & Donut1							
Birthweight > 5000*g*	0.0229***	0.0014	0.0002	0.0054	-0.0014**	-0.0008	-0.0010
	(0.0072)	(0.0165)	(0.0010)	(0.0094)	(0.0006)	(0.0009)	(0.0009)
N	45074	45203	45074	45074	45074	45074	45074
Panel D: BW 227g							
Birthweight > 5000*g*	0.0186**	0.0001	-0.0005	0.0036	-0.0017**	-0.0011	-0.0013
	(0.0093)	(0.0194)	(0.0012)	(0.0108)	(0.0007)	(0.0011)	(0.0010)
N	24339	24339	24339	24339	24339	24339	24339
Panel E: BW 227g & Donut							
Birthweight > 5000*g*	0.0218**	0.0005	-0.0006	0.0039	-0.0018**	-0.0012	-0.0014
	(0.0089)	(0.0198)	(0.0013)	(0.0110)	(0.0007)	(0.0011)	(0.0011)
N	24232	24232	24232	24232	24232	24232	24232
Panel F: BW 227g & Donut1							
Birthweight > 5000*g*	0.0210**	0.0001	-0.0006	0.0037	-0.0018**	-0.0012	-0.0014
	(0.0087)	(0.0198)	(0.0013)	(0.0112)	(0.0007)	(0.0011)	(0.0011)
N	24210	24210	24210	24210	24210	24210	24210

Notes: Authors' calculations using linked birth/death certificates data, 2007-2010. Separate linear trends in birth weight on each side of the 5000-gram cutoff are included and the regressions are weighted using triangular weights. All specifications control for: a dummy indicating whether the mother received more than 11 prenatal visits during pregnancy; age of the mother at child birth, and its square; a dummy indicating whether the mother has a college degree; a dummy indicating whether the information on a mother's education is missing; a dummy indicating whether the child was born after 39 weeks of gestation or more; a dummy indicating if the mother smoked during pregnancy; a dummy indicating whether the smoking information was missing; a dummy indicating if the mother is married; a dummy for the child's gender; a dummy indicating whether the mother had cesarean section in the previous pregnancy; the weight gain of the mother during pregnancy; dummy variables indicating whether the mother is white non-Hispanic, Hispanic or of another race non-Hispanic, respectively; cohort dummies. Sample of US births with birth weight between 4660 and 5340 grams, without missing observations in the above-mentioned variables. The specification *Donut* indicates that observations with birth weight equal to the cutoff have been dropped from the sample, while the specification *Donut1* indicates that also observations with birth weight within +/-1 gram from the cutoff have been excluded. Robust standard errors clustered at the gram level of birth weight are in parentheses. Asterisks denote statistical significance at the * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ levels.

For the baseline parametric analysis reported in Table 2, we chose a linear polynomial in birth weight because Figures 2 and 3 showed that treatment and mortality rates were generally relatively flat. Baseline results and robustness checks from parametric regressions in which we control for separate quadratic trends in the running variable on each side of the cutoff are shown in Appendix Table B.1. The results are by and large similar to those shown in Table 2, although there is sometimes a slight decrease in precision, which could be due to overfitting the data (particularly below the cutoff). The effects on NICU are precisely estimated and tend to be slightly larger than those in Table 2, while the effects on mortality tend to be slightly smaller and less precisely estimated. However, the NICU and mortality estimates from parametric regressions with quadratic polynomials tend to be within the 95% confidence intervals of the NICU and mortality estimates from parametric regressions with linear polynomials.

Finally, in order to reduce the potential bias introduced by a wrongly specified functional form, we also perform non-parametric estimation, by adopting two bandwidth specifications: the manual bandwidth has the same width as in the parametric regression (i.e., 340 grams from the 5000-gram cutoff); the optimal bandwidth is instead computed following the procedure proposed by Calonico et al. (2014), which is, in all cases, smaller than the manual one. Tables 3 and 4 report the results of the non-parametric analysis for the treatment and mortality outcomes, respectively. It is important to note that the non-parametric analysis with the optimally computed bandwidth also addresses the issue of markedly different sample sizes on either side of the 5000-gram cutoff since the method uses a more similar number of observations on both sides of the cutoff (see Column (1) in both Tables 3 and 4).

In the case of optimal bandwidth (Table 3, Panel A, Column (1)), while the estimate is less precise given the smaller sample size, we still find a positive and (marginally) significant effect of extremely HBW on the probability of being admitted to a NICU. The optimal bandwidth is determined to be about 62 grams and being born with an extremely HBW is estimated to increase the likelihood of being admitted to a NICU by about 2.9 percentage points, which translates into a 28% increase relative to the NICU admission rate among newborns within 62 grams below the 5000-gram cutoff (10.5%). When we use the manually selected bandwidth, the non-parametric regression results are very similar to those delivered by the parametric regressions. As in the parametric regression analysis, we do not find significant effects of being born with an extremely HBW on treatments other than NICU.

When we use the manual bandwidth of 340 grams, the non-parametric regression results for the mortality outcomes are again very similar to those that obtain in the parametric regression analysis (Table 4, Columns (2)-(7)). The effect of being born with an extremely HBW on 28-day mortality is statistically significant and estimated to be between -0.13 and -0.18 percentage points. The estimated effects on 180- and 365-day mortality risk are smaller and statistically insignificant. When the bandwidth is optimally computed for 28-day mortality, it is determined to be about 76 grams, and the estimated effect is again large and statistically significant at conventional levels. The estimated effect on 28-day mortality of being an extremely HBW newborn translates into a 160% decrease relative to the 28-day mortality rate among newborns within 76 grams below the 5000-gram cutoff (0.2%). In addition, when the bandwidth is optimally computed, the non-parametric regression results show similar-sized and (marginally) significant effects on 180- and 365-day mortality risk.

Table 3

Non-parametric regressions for treatments around the 5000-gram threshold.

	(1)	(2)	(3)	(4)	(5)	(5)	(5)
	Optimal BW	Manual BW					
		BW 340 g	BW 340 g & Donut	BW 340 g & Donut1	BW 227 g	BW 227 g & Donut	BW 227 g & Donut1
Panel A: NICU							
RDestimate	0.0286*	0.0260***	0.0235***	0.0230***	0.0253***	0.0218**	0.0211**
SE	(0.0163)	(0.0075)	(0.0072)	(0.0071)	(0.0092)	(0.0088)	(0.0087)
N-left	3088	37062	37062	37051	17960	17960	17949
N-right	2399	7724	7617	7606	6350	6243	6232
Bandwidth	61.8159	340	340	340	227	227	227
Panel B: C-section							
RDestimate	0.0166	0.0021	0.0017	0.0014	0.0010	0.0005	0.0001
SE	(0.0268)	(0.0160)	(0.0166)	(0.0166)	(0.0190)	(0.0199)	(0.0199)
N-left	4564	37062	37062	37051	17960	17960	17949
N-right	3176	7724	7617	7606	6350	6243	6232
Bandwidth	82.9338	340	340	340	227	227	227
Panel C: Surfactant							
RDestimate	0.0002	0.0001	0.0002	0.0002	-0.0007	-0.0006	-0.0006
SE	(0.0018)	(0.0010)	(0.0010)	(0.0010)	(0.0012)	(0.0013)	(0.0013)
N-left	6733	37062	37062	37051	17960	17960	17949
N-right	4083	7724	7617	7606	6350	6243	6232
Bandwidth	119.2924	340	340	340	227	227	227
Panel C: Ventilation							
RDestimate	-0.0089	0.0056	0.0055	0.0054	0.0041	0.0039	0.0038
SE	(0.0156)	(0.0089)	(0.0093)	(0.0094)	(0.0106)	(0.0111)	(0.0112)
N-left	4107	37062	37062	37051	17960	17960	17949
N-right	2462	7724	7617	7606	6350	6243	6232
Bandwidth	68.8194	340	340	340	227	227	227

Notes: The RD estimates are generated from local linear polynomial regressions, which were obtained using a triangular kernel function and two bandwidth specifications: the optimal bandwidth computed following the procedure proposed by Calonico et al. (2014), or a manually defined bandwidth of 340 grams or 227 grams. The specification *Donut* indicates that observations with birth weight equal to the cutoff have been dropped from the sample, while the specification *Donut1* indicates that also observations with birth weight within +/-1 gram from the cutoff have been excluded. All regressions control for the set of variables listed in Table 2. Sample of US births with birth weight between 4660 and 5340 grams, without missing observations in the variables listed in the footnote of Table 2. Robust standard errors clustered at the gram level of birth weight are in parentheses. Asterisks denote statistical significance at the * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ levels.

Table 4

Non-parametric regressions for mortality around the 5000-gram threshold.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Optimal BW	Manual BW					
		BW 340 g	BW 340 g & Donut	BW 340 g & Donut1	BW 227 g	BW 227 g & Donut	BW 227 g & Donut1
Panel A: 28-day mortality							
RDestimate	-0.0032**	-0.0013**	-0.0014**	-0.0014**	-0.0018**	-0.0018**	-0.0017**
SE	(0.0013)	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0007)
N-left	4375	37062	37062	37051	17960	17960	17949
N-right	3071	7724	7617	7606	6350	6243	6232
Bandwidth	76.1863	340	340	340	227	227	227
Panel B: 180-day mortality							
RDestimate	-0.0031*	-0.0009	-0.0008	-0.0008	-0.0013	-0.0012	-0.0012
SE	(0.0016)	(0.0009)	(0.0009)	(0.0009)	(0.0010)	(0.0011)	(0.0011)
N-left	4014	37062	37062	37051	17960	17960	17949
N-right	2458	7724	7617	7606	6350	6243	6232
Bandwidth	67.1380	340	340	340	227	227	227
Panel C: 365-day mortality							
RDestimate	-0.0030*	-0.0011	-0.0010	-0.0010	-0.0015	-0.0014	-0.0014
SE	(0.0016)	(0.0009)	(0.0009)	(0.0009)	(0.0010)	(0.0011)	(0.0011)
N-left	3077	37062	37062	37051	17960	17960	17949
N-right	2396	7724	7617	7606	6350	6243	6232
Bandwidth	60.9283	340	340	340	227	227	227

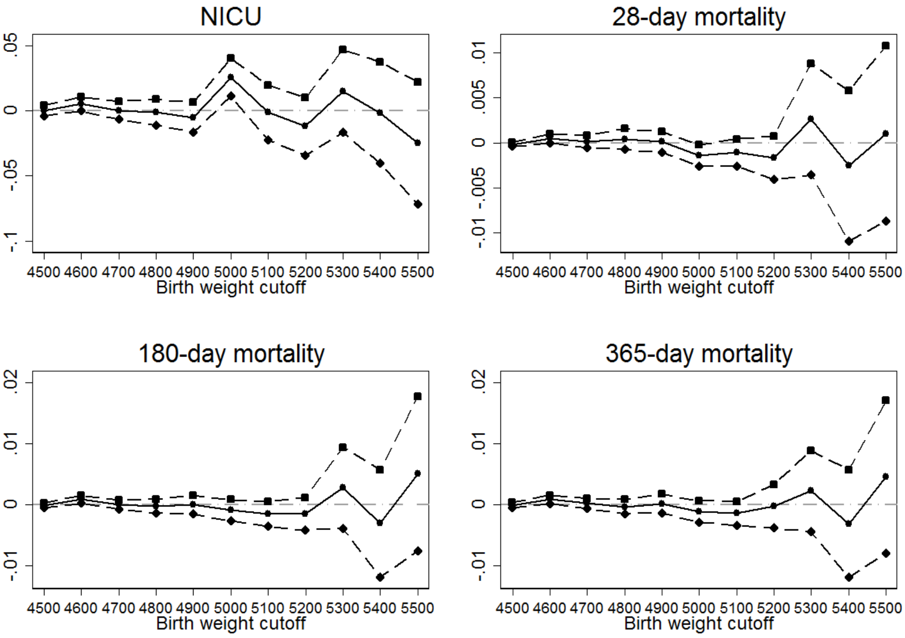
Notes: The RD estimates are generated from local linear polynomial regressions, which were obtained using a triangular kernel function and two bandwidth specifications: the optimal bandwidth computed following the procedure proposed by Calonico et al. (2014), or a manually defined bandwidth of 340 grams or 227 grams. The specification *Donut* indicates that observations with birth weight equal to the cutoff have been dropped from the sample, while the specification *Donut1* indicates that also observations with birth weight within +/-1 gram from the cutoff have been excluded. All regressions control for the set of variables listed in Table 2. Sample of US births with birth weight between 4660 and 5340 grams, without missing observations in the variables listed in the footnote of Table 2. Robust standard errors clustered at the gram level of birth weight are in parentheses. Asterisks denote statistical significance at the * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ levels.

As noted in Section 2, the medical literature suggests that other cutoffs at the upper portion of the birth weight distribution may be relevant for health treatment decisions, especially beyond 4500 grams (Chatfield, 2001, Gottlieb and Galan, 2007). To investigate other potentially important macrosomic thresholds, we estimate differences in NICU admission and mortality around 100-gram cutoffs between 4500 and 5500 grams. We use non-parametric regressions because the estimates are less sensitive to observations far from the thresholds and dissimilarity in the number of observations around the cutoff increases along the birth weight distribution. Figure 7 reports the non-parametric regression estimates, and the corresponding 95% confidence intervals, for each cutoff. For the analysis at each cutoff, we use the manual bandwidth of 340 grams for comparability with the baseline analysis. Appendix Figure B.1 reports the estimates obtained by using an optimally-computed bandwidth. Reassuringly, both figures show a statistically significant difference in both NICU admission and mortality only at the 5000-gram cutoff.[16]

Overall, results from the non-parametric regressions mirror those of the parametric regressions. Being born to the right of the 5000-gram birth weight cutoff results in a large increase in the probability of being admitted into a NICU. Consistent with this differential treatment, being born with a birth weight above 5000 grams reduces the risk of 28-day

[16] We have also conducted analyses centered at macrosomic cutoffs at the lower end of the macrosomic birth weight distribution (i.e. 4000-4500 grams). We did not detect any evidence of discontinuity in these cases, neither for treatments nor infant mortality outcomes. Results are available upon request.

Figure 7
Non-parametric estimates for NICU and mortality outcomes at cutoffs between 4500 and 5500 grams, by using a manual bandwidth of 340 grams.



Notes: The solid lines represent RD estimates from local linear regressions, around cutoffs every 100 grams in the range 4500 - 5500 grams, using, for each estimation, a bandwidth of 340 grams, controlling for the set of variables listed in Table 2 and clustering the standard errors at the gram level of birth weight. The dashed lines represent the 95% confidence interval. Sample of US births with birth weight within 340 grams from each cutoff, without missing observations in any of the variables listed in Table 1.

mortality and the downward pressure on infant mortality risk may linger through the first year of life. Taken together, all the results discussed above clearly point toward NICU admission being assigned according to where a newborn weighs-in relative to the 5000-gram cutoff and, in turn, the extra medical care that the heavier macrosomic babies receive in the NICU leads to a considerable reduction in the risk of infant mortality. A possible interpretation of the heterogeneity in findings across macrosomic cutoffs is that the *rule of thumb* determining health treatments is more relevant at the relatively riskier high end of the birth weight distribution. This accords well with evidence of rules of thumb used at the lower end of the birth weight distribution, where treatment discontinuities exist among very LBW children but not (heavier) LBW children (Almond et al., 2010).

6 Conclusions

In this study, we estimate the short-run health returns to providing extra medical care to macrosomic newborns. In a regression discontinuity framework, we find that there is an economically important and statistically significant effect of being born with an extremely HBW on NICU admission. In line with the difference in the probability of NICU admission, which depends on where in the birth weight distribution a newborn weighs-in relative to the 5000-gram cutoff, we also find that being born with an extremely HBW substantially reduces the risk of infant mortality. These findings are consistent with what studies have found at the lower end of the birth weight distribution. Given the very low mortality rate in our sample of newborns below the 5000-gram cutoff, the estimated effect of being born with an extremely HBW on mortality risk is very large.

We use a recent study that found heterogeneity in both NICU admission and mortality around the 1500-gram cutoff to get a sense of how the returns to extra medical care might compare at opposite ends of the birth weight distribution. Bharadwaj et al. (2013) find that, among Norwegian newborns born at 32 weeks or greater, being born with a very LBW increases the likelihood of being transferred to a NICU by about 50% and decreases the risk of 1-year mortality by about 86%. While our estimated effect of being extremely HBW on NICU admission is smaller than 50%, our estimated 28-day mortality effect is larger than 86%. Taken together, our findings suggest that the health returns to extra medical care may be heterogeneous along the birth weight distribution and may translate into a greater reduction in infant mortality risk at the high end of the macrosomic segment of the birth weight distribution. These findings are important in light of the fact that maternal obesity, a major risk factor for macrosomia, is becoming more prevalent, which, as a consequence may result in a greater number of medical providers facing rule-of-thumb health treatment decisions at macrosomic cutoffs.

It is important to note that, while we find a large discontinuity in NICU admission at the 5000-gram cutoff, we cannot isolate the specific medical inputs provided to macrosomic infants in NICUs that translate into sizeable short-run health gains. We did not find similar discontinuities in respiratory treatments (ventilation and surfactant),[17] suggesting that other medical inputs may be important for improving the health of macrosomic infants. Shedding more light on this issue, including pinning down the type and quantity of medical inputs provided to macrosomic infants, would allow for a nuanced analysis of heterogeneity in the returns to medical care at different points of the birth weight distribution. Another important issue to bear in mind is that infant mortality is an

[17] Interestingly, Bharadwaj et al. (2013) found evidence suggesting that surfactant therapy, in particular, plays a role in the link between neonatal care and mortality risk among very LBW newborns.

extreme health event, so future work on whether additional medical care upon delivery of macrosomic newborns results in other health or non-health improvements after birth is warranted.[18] Additional evidence in this regard would also allow for a more comprehensive comparison of the costs and benefits associated with extra medical care for macrosomic babies.

[18] Cesur and Kelly (2010) present evidence suggesting that math and reading achievement is adversely affected by a HBW outcome (>4500 grams).

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A Determinants of an extremely HBW outcome

Table A.1
Analysis of determinants of having a birth weight heavier than 5000 grams.

	Birthweight > 5000*g*	
	OLS	Logit
N. Prenatal visits > 11	-0.0005	-0.0037
	(0.0036)	(0.0259)
Mother's age	0.0043*	0.0317*
	(0.0025)	(0.0191)
Mother's age squared	-0.0000	-0.0003
	(0.0000)	(0.0003)
Mother has at least a college degree	-0.0239***	-0.1718***
	(0.0050)	(0.0270)
Mother's education missing	-0.0354	-0.2632
	(0.0235)	(0.1834)
Term birth	-0.0252***	-0.1705***
	(0.0065)	(0.0330)
Mother smoked in pregnancy	-0.0015	-0.0101
	(0.0095)	(0.0679)
Smoking info missing	0.0030	0.0218
	(0.0226)	(0.1573)
Married mother	-0.0020	-0.0135
	(0.0055)	(0.0392)
Male	0.0014	0.0100
	(0.0036)	(0.0260)
Mother had previous c-section	0.0436***	0.2910***
	(0.0065)	(0.0302)
Mother weight gain	0.0013***	0.0094***
	(0.0003)	(0.0017)
White non-hispanic	-0.0225***	-0.1548***
	(0.0075)	(0.0568)
Hispanic	-0.0134*	-0.0901*
	(0.0074)	(0.0528)
2008 cohort	0.0065	0.0471
	(0.0054)	(0.0379)
2009 cohort	0.0038	0.0273
	(0.0055)	(0.0407)
2010 cohort	0.0066	0.0474
	(0.0048)	(0.0361)
constant	0.0879*	-2.2067***
	(0.0463)	(0.3920)
R-squared	0.0065	
Pseudo R-squared		0.0070
N	45203	45203

Notes: Authors' calculations using linked birth/death certificates data, 2007-2010. Sample of US births with birth weight between 4660 and 5340 grams, without missing observations in the listed variables. Robust standard errors that are clustered at the gram level of birth weight are in parentheses. Asterisks denote statistical significance at the * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ levels.

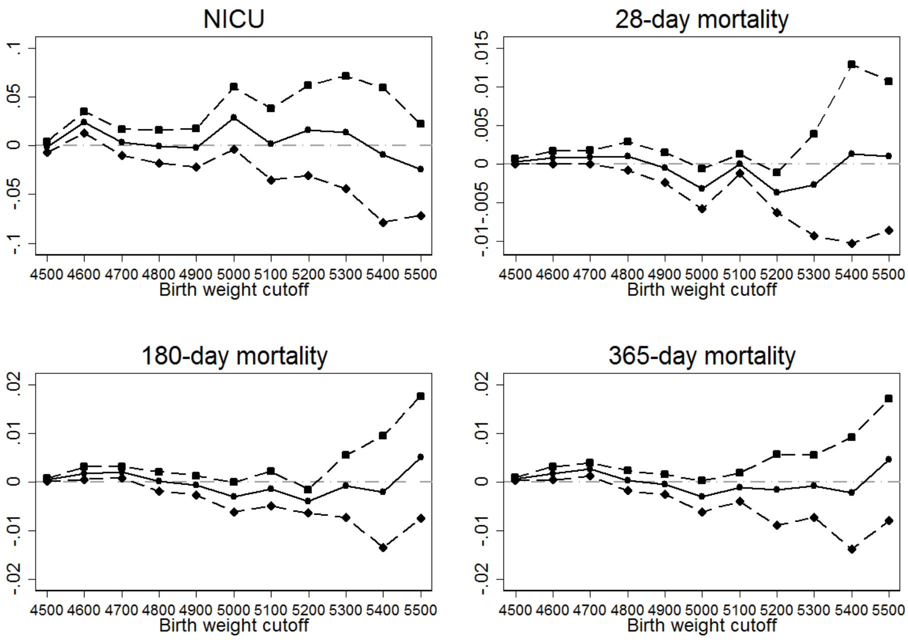
B Additional results

Table B.1
Parametric regressions for treatments and mortality outcomes. Quadratic specifications.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	NICU	C-section	Surfactant	Ventilation	28-day mortality	180-day mortality	365-day mortality
Panel A: Baseline BW 340g							
Birthweight $> 5000g$	0.0316***	0.0201	0.0009	0.0093	-0.0007	-0.0002	-0.0003
	(0.0058)	(0.0125)	(0.0008)	(0.0071)	(0.0005)	(0.0007)	(0.0007)
N	45203	45203	45203	45203	45203	45203	45203
Panel B: BW 340g & Donut							
Birthweight $> 5000g$	0.0328***	0.0204	0.0009	0.0094	-0.0007	-0.0003	-0.0004
	(0.0056)	(0.0125)	(0.0008)	(0.0071)	(0.0005)	(0.0007)	(0.0007)
N	45096	45096	45096	45096	45096	45096	45096
Panel C: BW 340g & Donut1							
Birthweight $> 5000g$	0.0325***	0.0203	0.0009	0.0094	-0.0007	-0.0003	-0.0004
	(0.0056)	(0.0125)	(0.0008)	(0.0072)	(0.0005)	(0.0007)	(0.0007)
N	45074	45074	45074	45074	45074	45074	45074
Panel D: BW 227g							
Birthweight $> 5000g$	0.0264***	0.0121	0.0001	0.0081	-0.0011*	-0.0006	-0.0007
	(0.0070)	(0.0151)	(0.0009)	(0.0087)	(0.0006)	(0.0008)	(0.0008)
N	24339	24339	24339	24339	24339	24339	24339
Panel E: BW 227g & Donut							
Birthweight $> 5000g$	0.0284***	0.0126	0.0000	0.0084	-0.0011**	-0.0006	-0.0008
	(0.0067)	(0.0152)	(0.0009)	(0.0088)	(0.0006)	(0.0008)	(0.0008)
N	24232	24232	24232	24232	24232	24232	24232
Panel F: BW 227g & Donut1							
Birthweight $> 5000g$	0.0281***	0.0124	0.0000	0.0083	-0.0011*	-0.0006	-0.0008
	(0.0067)	(0.0152)	(0.0009)	(0.0089)	(0.0006)	(0.0008)	(0.0008)
N	24210	24210	24210	24210	24210	24210	24210

Notes: Authors' calculations using linked birth/death certificates data, 2007-2010. Separate quadratic trends in birth weight on each side of the 5000-gram cutoff are included and the regressions are weighted using triangular weights. All specifications control for the variables listed in the footnote of Table 2. Sample of US births with birth weight between 4660 and 5340 grams, without missing observations in the above-mentioned variables. Robust standard errors clustered at the gram level of birth weight are in parentheses. Asterisks denote statistical significance at the * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ levels.

Figure B.1
Non-parametric estimates for NICU and mortality outcomes at cutoffs between 4500 and 5500 grams, by using an optimally computed bandwidth.



Notes: The solid lines represent RD estimates from local linear regressions, around cutoffs every 100 grams in the range 4500 - 5500 grams, using, for each estimation, the optimal bandwidth computed according to Calonico et al. (2014), controlling for the set of variables listed in Table 2 and clustering the standard errors at the gram level of birth weight. The dashed lines represent the 95% confidence interval. Sample of US births with birth weight within the optimally computed bandwidth from each cutoff, without missing observations in any of the variables listed in Table 1.