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Low birth weight and health expenditures from birth to late adolescence[1]

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Abstract

Using administrative panel data of health insurants, we estimate the effects of low birth weight on health service utilization among children and young adults between birth and 21 years old. To account for time-invariant heterogeneity of mothers, we use sibling fixed-effects estimation. We find that low birth weight strongly increases subsequent health expenditures and that the effect is particularly pronounced in the first year of life. Starting in compulsory schooling, we observe a shift in expenditures to mental-health problems. Whereas the effects on physical health disappear over time, we provide evidence that mental-health problems prevail until early adulthood. We therefore suggest a screening program tailored to the conditions more likely to be contracted by low-birth-weight children in order to mitigate the negative health consequences.

JEL Classification: I10, I12, I18

Keywords: Low birth weight, health expenditures, sibling fixed-effects

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1. Introduction

Low birth weight (LBW) among babies has been established as a leading indicator of the physical and cognitive development of newborns during pregnancy. The argument is that—beyond genetic predisposition—the behavior of expectant mothers and external (environmental) influences in utero may have persistent and negative effects on children. These negative impacts on the fetus are reflected by LBW, with a critical threshold of less than 2,500 grams.[2] The major finding of the (predominantly Anglo-Saxon) health economics literature is that LBW babies have worse short- and long-term outcomes: (i) LBW entails high direct neonatal treatment costs, (ii) LBW babies have a higher probability of infant mortality, (iii) there is evidence of lower educational attainment and labor market outcomes among those with LBW, and (iv) LBW may cause negative long-term health consequences.[3] The relevance of the negative effects of LBW on short- and long-term outcomes to health policy is obvious, since the issue is closely connected to the question of whether, and to what extent, socio-medical interventions during pregnancy would be meaningful, not only from a medical but also from an economic perspective.

The majority of the economic literature on the effects of LBW focuses on either the period immediately after birth or on health in adulthood. However, the economic evidence concerning the effects of LBW in childhood and adolescence is sparse. In this paper, we therefore, analyze the development of LBW newborns' health care utilization during their early years of life. This should improve our understanding of how LBW affects children throughout the early life cycle and should in turn help to mitigate the negative consequences of LBW. For that purpose we use Austrian administrative health service data linked to the Austrian birth register to study the impact of LBW and very low birth weight (VLBW) — defined as birth weight less than 1500 grams — on health outcomes during childhood and early adulthood. We use the variable VLBW to identify (heterogeneous) effects for those children with a birth weight at the very low end of the distribution. Comprehensive individual health insurance records provided by the mandatory regional sickness fund for the state of Upper Austria allow a thorough analysis of health service utilization, such as the number days hospitalized, expenditures on medical drugs, and medical attendance among different age cohorts. To address the potential influence of unobserved variables, we control for time-invariant unobserved

[2] The World Health Organization (WHO) uses the incidence rate of babies with LBW as an indicator of a multifaceted public health problem (see the WHO Statistical Information System, http://www.who.int/whosis/indicators/compendium/2008/2bwn/en).

[3] Currie (2009) provides an excellent literature review on the links between the health of children and their future education or income with a particular focus on the role of birth weight. For an example of a paper discussing the effects of LBW on future health, see Kramer (1987a).

heterogeneity by including sibling fixed-effects. We find that LBW infants—in comparison to their normal-birth-weight (NBW) counterparts—spend more days hospitalized and spend more on medical drugs (particularly on anti-infectives) in their first year of life. Although the absolute differences in health service utilization between NBW and LBW groups diminish over time, LBW newborns still spend more days hospitalized, and their expenses on medical drugs and medical assistance are significantly higher, in early childhood. During compulsory schooling, we observe a shift towards diseases of the nervous system and mental and behavioral disorders among children born with LBW that is evidenced, among other outcomes, by an increase in consumption of drugs affecting the nervous system and by their higher utilization of psychotherapy and logopedic and phoniatric therapy. Some of these effects persist until early adulthood.

Empirical economic and epidemiological research on birth weight is found in two different strands of literature. One branch analyzes birth weight as the output of prenatal health factors with a focus on maternal behavior during pregnancy (see Almond, 2005 and the literature cited therein). The second strand of literature focuses on birth weight as a proxy (input) of a newborn's initial endowment of health capital. The upshot of this empirical research is that LBW has persistent and negative long-term effects on economic, educational, and health outcomes.[4]

The available empirical evidence is often cross-sectional, and the presented association between LBW and the costs it imposes upon society may be biased by omitted variables, such as genetics. Consequently, a series of recent papers have controlled for observed and unobserved heterogeneity among mothers by exploiting within-twin variation in birth weight. Behrman and Rosenzweig (2004) use data on female monozygotic twins born between 1936 and 1955 from the Minnesota Twin Registry and find that an increase in fetal growth has significantly positive effects on educational attainment, wages, and adult height. They also show that twin fixed-effects estimates are quantitatively larger than those from cross-section specifications. Similarly, Almond et al. (2005) analyze twin pairs born in the U. S. between 1983 and 2000. They find short-term health effects of LBW that are a fraction of those found in more-conventional cross-sectional evidence. In cross-section specifications, an increase in birth weight by one standard deviation is associated with an increase in Apgar scores, a reduction in infant mortality, a reduction in assisted ventilator use after birth, and a decrease in hospital costs, all by 0.25–0.51 standard deviations. In contrast, the corresponding figures are 0.01–0.08 standard deviations in the twin specifications. In their analysis of twin births in the 1995–1997 U. S. Matched Multiple

[4] For predominantly cross-sectional evidence on the effects of LBW in non-economic disciplines, see, for instance, the surveys by Pojda and Kelley (2000), Ashdown-Lambert (2005), and Aarnoudse-Moens (2009).

Birth Data Set, Conley et al. (2006) provide estimates of similar magnitudes of the effects of birth weight on infant mortality. The authors further show that the relative impacts of genes and prenatal environment vary by length of gestation. The intrapair variation in prenatal environment seems to be particularly important in determining the negative association between birth weight and infant mortality in pregnancies with gestation lengths of below 37 weeks.

Black et al. (2007) provide influential evidence of both short-term and long-term outcomes of LBW. The authors use within-twin variation in a rich administrative dataset from Norway and find significantly negative impacts of LBW on adult height, IQ, and educational attainment. They estimate that a 7.5-percent increase in birth weight would increase adult height by 0.2 centimeters, the stanine IQ score by 0.05, and full-time earnings by 1 percent.[5] Similarly, Oreopoulos et al. (2008) use sibling and twin variation in Canadian data and find that LBW is a strong predictor of high school completion and welfare receipt and duration.

This paper contributes to the literature on birth weight as an initial endowment for future health capital in several respects: (i) the analysis is not restricted to outcomes that are only available at a particular point in time. We observe health-related outcomes for individuals between birth and 21 years old for periods of up to five years. (ii) The exceptionally detailed data on health care consumption provided by a mandatory state-level sickness fund include days hospitalized (and admission diagnoses[6]), ambulatory doctor visits, and medical drug consumption. Moreover, the consumption of medical drugs is classified according to the Anatomical Therapeutic Chemical System (ATC) of the WHO. Given that we also observe the medical specialties of resident doctors seen by the children in the sample, we analyze in detail the medical conditions from which children born with LBW are more likely to suffer in their first 21 years of life.[7] (iii) In contrast to the majority of existing studies, we focus on a Bismarckian-type health insurance system that provides universal health care and guarantees free access to services for all residents covered by mandatory health insurance.

Different from the above-mentioned papers that use variation in birth weight within twins, we analyze single births and control for sibling fixed-effects.[8] It is generally acknowledged

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[5] The twin fixed-effects estimates of LBW on short-term outcomes such as Apgar scores and infant mortality obtained by these researchers are, however, quantitatively very small.

[6] Diseases are coded according to ICD-10, the International Statistical Classification of Diseases and Related Health Problems.

[7] Concerning the structure of data, the study by Currie et al. (2010) is the most similar to ours. The authors use public health insurance records of persons born in the Canadian province of Manitoba between 1979 and 1987. These data, which are available for at least twenty years after birth, are linked with administrative records on education and welfare receipt. However, the data do not include information on the consumption of medical drugs, and the focus of the paper is on health problems in early childhood that the authors find to be significant predictors of outcomes in young adulthood.

[8] Previous studies that used sibling fixed-effects were those by Conley and Bennett (2000), who use U. S. panel data and find that LBW results in lower educational attainment after correcting for other factors,

that LBW is governed by two different factors: short gestation duration and/or intrauterine growth restriction (IUGR; reduced fetal growth for a given gestation duration). Though gestation duration is empirically the most important determinant of LBW in the developed world, most health economics research has focused on IUGR (Kramer 1987b). Twin analysis obviously controls for mother-specific factors, and the observed intrapair differences in birth weight are necessarily due to fetal growth retardation given that twins have identical gestational duration. In contrast, our analysis of singleton births controls for time-invariant, unobserved mother heterogeneity, whereas time-dependent, unobserved characteristics of mothers cannot be taken into account. In particular, we do not control for gestational length. Consequently, we cannot distinguish between prematurity and IUGR as the main reasons for LBW.[9] Although it is desirable from an econometric perspective to control for all mother-specific factors[10], twin analysis is not without caveats. For example, Almond et al. (2010, p. 1040) concede that the identities and relative contributions of the environmental factors that cause intrapair variation and their modifiability are unknown, although they observe that within-twin variations in birth weight are large in their pooled sample of twins. Moreover, it remains somewhat unclear whether within-twin variation may predict the impacts of caloric intake on health outcomes in single births. Black et al. (2007, p. 435f) argue that there are substantial differences between single and twin births, the most remarkable difference being that twins fall disproportionally into the lower part of the birth-weight distribution. However, they argue that, conditionally depending on birth weight, the outcomes (mortality, height, IQ, earnings) of singletons and twins are similar, and their results may be generalizable to the rest of the population. Moreover, the authors show that sibling fixed-effects estimates of later outcomes are quite similar to twin fixed-effects estimates. As compared to twin analyses, we would therefore not expect substantial differences in results based on our identification strategy, which controls for time-invariant mother heterogeneity (sibling fixed-effects).[11]

The remainder of the paper is organized as follows: Section 2 discusses the institutional setting of the Austrian health system with a focus on pre- and postnatal service utilization. The

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and by Currie and Moretti (2007), who found a 50-percent-higher probability that a child had LBW if the mother had LBW by reviewing California birth certificate data. Moreover, the authors find, after controlling for grandmother fixed-effects, that being born with LBW has significant and negative effects on later socioeconomic achievements. For a more recent contribution including sibling fixed-effects, see Johnson and Schoeni (2010), who found that LBW increased the probability of failure to complete high school and decreased labor market participation and wages.

[9] Even if we wished to analyze intrapair birth-weight variation, records of health service consumption could not be unequivocally verified for same-sex twins in the sickness fund database.

[10] To make sure to control for all unobserved heterogeneity (including genetic endowment), the analysis needs to be restricted to monozygotic twins only.

[11] Finally, twin (and sibling) fixed-effects may be biased if parents invest differently in one or the other sibling. If parents favor the disadvantaged child, sibling fixed-effects understate the true effects of birth weight. However, the effects tend to be overstated if parents invest more in the stronger child.

section also includes a description of the data, presents descriptive statistics, and outlines our methodology. Section 3 presents our empirical results and their interpretation. Section 4 concludes the paper.

2. Institutional setting, data, and estimation strategy

Austria has a Bismarckian-type social health insurance system, with every resident being covered by mandatory health insurance. The assignment of employees and their dependents to a sickness fund depends on the employers' location and the type of occupation. Therefore, sickness funds cannot be freely chosen by the insurant. The sickness fund covers all costs associated with sickness and maternity and the utilization of both inpatient and outpatient health-care services. Therefore, health-service utilization is not restricted by financial constraints.[12] Although there is no mandatory gatekeeping system in the Austrian outpatient sector, it is recommended that patients first visit their GPs before consulting medical specialists.[13] According to our data, 24 percent of all specialists' services are provided after a referral from a GP. Dentists and pediatricians are not included in this computation, since these doctors are typically consulted directly. In fact, for both of these types of medical attendance, the referral rate is only about three percent.

As in many other countries, prenatal care in Austria is expected to identify mothers at risk of delivering LBW babies and to intervene if necessary. Such interventions include medical treatment, nutrition advice, and general lifestyle counseling.[14] Consequently, prenatal care is an important instrument to improve the health of unborn children. All Austrian sickness funds provide comprehensive pre- and postnatal screening programs. Expectant mothers are strongly recommended to participate in these programs, the costs of which are fully covered by the funds. The prenatal part of the program consists of five basic examinations conducted at predetermined points in time during pregnancy. Since in our data set, 96 percent of all mothers participate in all five basic exams,[15] we conclude that variations in birth weight are unlikely to be caused by differences in prenatal care uptake rates among expectant mothers.

Figure 1 shows that the incidence of LBW in Austria declined until the mid-1990s and started to increase thereafter. This holds true for the share of very-low-birth-weight (VLBW) as well as the share of LBW babies. The dotted line in this figure suggests that the increase in the share of LBW babies might be driven by an increase in the percentage of multiple births. This suggestion is supported by the fact that the share of LBW births among singletons has remained constant over time, whereas it has increased for multiple births. The rise in the share of multiple births is, in turn, likely attributable to the increased utilization of assisted reproductive technology, particularly in-vitro fertilization (IVF). The mother of the first Austrian in-vitro baby

[12] In fact, 90 percent of individuals in our sample have at least one contact with the health system per year.
[13] Patients need referrals from their GPs only for consultations with radiologists.
[14] For the general role of prenatal care, see e.g., Alexander and Korenbrot (1995).
[15] There is a strong financial incentive to take the exams, as eligibility for several family benefits depends on proof of participation.

gave birth in 1982, and from then, the share of multiple births has steadily increased.[16] Since we do not have IVF data from the 1980s or 1990s, we can only hypothesize that the increased use of IVF may have contributed to the increase in multiple births. Aggregate IVF data are available for the period between 2001 and 2005, and it is reported that the number of IVF pregnancies increased by almost 60 percent during this period.[17] The steep ascent (0.5 percentage points) in multiple births from 2000 to 2001 supports this claim.[18] This development therefore suggests that LBW is of increasing importance to the health system.

Data

Our empirical analysis uses detailed administrative data from the *Upper Austrian Sickness Fund* and the *Austrian birth register*. The *Upper Austrian Sickness Fund* covers all private employees and their dependents in the province of Upper Austria. The 1.1 million insurants constitute 75 percent of the provincial population. The fund's health records include individual information on doctor visits, medical drug consumption, and the number of days spent hospitalized. We aggregate these data to construct the yearly incidence of hospitalization, expenditures on medical drugs, and medical attendance for each child and young adult from 2005 through 2009. We classify prescribed drugs on the basis of the Anatomical Therapeutic Chemical (ATC) Classification System code, which allows a detailed division of medical drugs according to the organs on which they act. Similarly, by using the ICD-10 (International Statistical Classification of Diseases and Related Health Problems) classification system advocated by the WHO, we classify the number of days spent hospitalized according to the main admission diagnoses.[19] Both classification systems allow for more detailed insight into the conditions from which LBW children most likely suffer.

It must be noted, however, that our consumption data regarding health services might not perfectly reflect the health statuses of individuals. Certain health care services have a clear preventive character (e.g., postnatal screenings of newborns, routine dental visits, or other check-ups), and health-conscious people are likely to utilize these services more often than are less health-conscious people. If a child was born with LBW, a mother may be more concerned about the health of her child and therefore demand preventative health services more frequently. In addition, physicians may also be more risk-averse in those cases and may conduct diagnostic tests more often. Therefore, higher health-service utilization may not only indicate

[16] http://sciencev1.orf.at/science/news/56345. Accessed: February 10, 2012.
[17] http://www.ivf-gesellschaft.at/index.php?id=30. Accessed: February 8, 2012.
[18] Starting in 2000, the Austrian government has covered 70 percent of the costs of in-vitro fertilization under certain circumstances. This change is likely to result in increased utilization and may therefore explain the increase in the rate of multiple births from 2000 to 2001.
[19] For further information on these systems, see http://www.whocc.no/atc/structure_and_principles/ and http://www.who.int/classifications/icd/en/.

the worse health status of LBW children, but also reflect more risk-averse behavior by their mothers and/or physicians. Even if we cannot unequivocally distinguish the health effect from the risk-aversion effect, the level of detail in our data allows us to determine whether expenditures reflect the utilization of curative (to improve poor health) or preventive (to maintain good health) services. For instance, we interpret time spent hospitalized and consumption of medical drugs as better indicators of health status than expenditures on medical attendance at the offices of certain types of ambulatory doctors.

We link individual health service data with the *Austrian birth register* to obtain information on newborns' birth weights.[20] The birth register includes information on all births from 1984 to 2007. Given the structure of our data, we cannot observe health-service utilization over a child's complete life cycle. For each individual, utilization data is available for a maximum of five consecutive years. Since births to the same mother can be linked, we include sibling fixed-effects in our analysis to account for time-invariant unobserved heterogeneity. Consequently, we restrict our data set to siblings. On average, we observe 2.39 siblings per mother and year, and the average age difference between the children is 3.6 years. The resulting unbalanced panel data include information on the yearly outcomes of 113,064 siblings between birth and 21 years old. Infants enter the sample either in the year of birth or when they join the sickness fund afterwards. Children and young adults drop out of the sample if they change their sickness fund within the province of Upper Austria (because of a new employer), they move to another province, or they die. We consider it highly unlikely for parents to change their sickness fund because their infants' health conditions require expensive medical treatments, as all sickness funds cover almost an identical spectrum of services with only minor differences in deductibles and copayments.[21] The majority of children in our sample (72.65 percent) can be observed in each year of the observation period. About four percent cannot be observed in each year because they were born after 2005. The remaining children left the sample during the observation period.

Table 1 presents aggregated outcomes by birth weight categories and age groups. The panel for NBW children shows a familiar pattern: both days of hospitalization and outpatient expenditures are highest for the youngest age group (0–1 years old).[22] Outpatient expenditures and days hospitalized decrease with age with the exception of expenditures on medical drugs; this cost component increases from €25.4 per year in the youngest age group to almost €37 for those between 15 and 21 years old. In general, expenditures and days of hospitalization for LBW

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[20] The data match is, however, restricted to singletons, as we cannot unambiguously identify the individuals from same-sex multiple births in sickness fund records.

[21] Moreover, as was mentioned above, employees cannot freely change their sickness funds. Moving to another health insurer is only possible if a person gets a new job in the public sector or with specific employers such as the Austrian railway company.

[22] This group includes newborns and infants up to one year and 11 months old.

and VLBW children are higher than those for the NBW group. Particularly striking are the differences in the first years of life. The number of days spent hospitalized among the 0–1-year-old age group varies from 1.2 (NBW) to 6.4 (LBW) to more than 26 days (VLBW). The same pattern holds true for expenditures on medical drugs. Whereas average expenditures on medical drugs among the 0–1-year-old age group of NBW (LBW) babies are €25.4 (€88.3) per year, this amount is €967 for their VLBW counterparts. The general impression gleaned from Table 1 is that differences in outcomes between the birth weight categories decrease with increasing age; however, some differences persist until young adulthood, as can be seen from the figures for the 15–21-year-old age group.

Estimation strategy

To identify the impacts of VLBW and LBW on health throughout the early life cycle, we estimate the subsequent equation for the following age groups: infancy and early childhood (age groups 0–1 and 2–5 years), compulsory schooling (age group 6–14 years), and adolescence and early adulthood (age group 15–21 years):

$$y_{ijt} = \alpha + \beta_1 vlbw_{ij} + \beta_2 lbw_{ij} + \beta_3 X_{ijt} + \beta_4 age_{ij} + \mu_j + \lambda_t + v_{ijt}$$

where y_{ijt} denotes the outcome of child *i* with mother *j* at time *t*. The dummy variables $vlbw_{ij}$ and lbw_{ij} indicate whether a baby was born with VLBW (below 1,500 grams) or with LBW (between 1,500 and 2,500 grams), respectively. X_{ijt} is a vector of child controls, including age and sex of the child, number of siblings, and birth order of the child.[23] One might argue that gestational duration represented another important control in this equation, as it is likely to be correlated with health. However, the duration of gestation is simultaneously determined with birth weight and can therefore be considered a bad control (Angrist, 2008, 46ff). Consequently, we do not control for gestational duration. Moreover, we include the mother's age at birth, age_{ij}, and period dummies λ_t. If there are unobserved covariates that correlate with outcome and birth weight, OLS results may be subject to omitted-variable bias. Therefore, we control for time-invariant, unobserved family characteristics by introducing sibling fixed-effects, denoted by μ_j.[24] However, if there is any time-variant variable that correlates with birth weight and outcome, a sibling fixed-effects estimation may fail to identify the true causal effects. Finally, v_{ijt} denotes the error term.

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[23] Birth weight increases with the number of deliveries, and a mother may change her behavior with subsequent children if she becomes more experienced.

[24] In principle, the panel structure would allow to control for time-invariant heterogeneity of infants. However, since birth weight does not vary over time, it is not feasible to identify the effects of LBW if individual fixed-effects are included.

LBW can originate from two sources: (i) intrauterine growth restriction (IUGR) and (ii) prematurity. In the first case, a fetus does not grow at the normal rate and is more likely to be small for its gestational age. If there are two newborns from a multiple birth, and one is affected by IUGR, then the affected infant is more likely to have LBW, even though both spent the same time in utero. Differences in birth weight are therefore solely caused by intrauterine growth rates. On the contrary, prematurity describes that a baby has LBW since she was born too early and not because of retarded growth. This distinction has important implications for the analysis of twin pairs. Twin studies restrict the source of variation in birth weight to intrauterine growth restriction, since twins spend—by definition—the same amount of time in utero. Kramer (1987b), however, states that LBW in developed countries is mainly determined by prematurity. We have recognized that the siblings approach cannot control for the full spectrum of unobserved heterogeneity, such as twin fixed-effects. However, if one controls for twin fixed-effects, the source of variation is restricted to IUGR, since gestational duration is the same among a twin pair. The inclusion of twin fixed-effects might therefore underestimate the effects of LBW in developed countries.[25] It is important to note that sibling fixed-effects might control for gestational age if it is identical among siblings. In fact, our data show that the variation in gestational duration for one mother over the course of different births is moderate. The duration of gestation differs by one week or less for 68.5 percent of siblings in our data set.

[25] However, a smaller effect of LBW in twin fixed-effects estimations can also be caused by omitted variables for which we do not control in our specification including sibling fixed-effects.

3. Empirical Results

In this section, we present our estimation results. First, we present OLS results for our main outcomes (days spent hospitalized, outpatient expenditures on medical drugs, and medical attendance) in Table 2. Sibling fixed-effects estimations for the same outcomes are shown in Table 3. Both tables include results for children born with VLBW and LBW. A comparison of the pooled regression results and the fixed-effects results reveals that the OLS estimates are generally upward biased, particularly in the first year of life. However, the bias between the OLS and fixed-effects results decreases with age. This implies that unobserved family characteristics correlate with birth weight and outcomes and that this correlation weakens with age. Consequently, we focus on the results of the fixed-effects estimations. We begin the discussion by summarizing the effects during infancy and early childhood.

3.1 Infancy and early childhood

As shown in Table 3, VLBW infants spend 14.9 more days hospitalized (1,231 percent)[26] in their first year of life than do their NBW counterparts, suggesting that newborns weighing below 1,500 grams require significantly more inpatient care immediately after birth.[27] For LBW infants, their 4.3 days of hospitalization is still 355 percent higher than the number of days spent hospitalized by the NBW reference group. In order to analyze the determinants of inpatient stays in more detail, we split hospitalization time according to the ICD-10 classification. This decomposition, presented in Table 4, shows that for VLBW newborns in their first year of life, an average of 10.4 out of the total 14.9 days spent hospitalized can be explained by "certain conditions originating in the perinatal period." This diagnosis code includes, among other maladies, the symptoms of short gestational duration, respiratory distress, low birth weight for a given gestational age, and extreme immaturity. The most common medical services that are provided for these newborns include noninvasive, intensive monitoring; general intensive care; respiratory therapy; continuous monitoring of fluid balance; and partial parenteral nutrition. In contrast, for LBW infants, only one third of total inpatient time (1.3 out of 4.3 days of hospitalization) is attributable to "certain conditions originating in the perinatal period," but almost 40 percent of inpatient time is caused by diseases of the respiratory system. Another significant effect observed regarding hospitalization is that VLBW infants have a higher risk than others to contract diseases of the nervous system in their first year of life. In particular, VLBW newborns suffer more often from epilepsy and sleep apnea. These diagnoses contribute to 0.42

[26] Percentages are calculated with reference to the means among NBW infants throughout the text.
[27] Note that our sample only includes infants who survived the first month of life. An additional selection process may take place when a fetus dies during pregnancy and is not born with low birth weight. Therefore, the estimates are likely to represent the lower bounds of the effects.

days spent hospitalized, during which the young patients mainly receive magnetic resonance tomography (under anesthesia) and general intensive care.

Although the hospitalization time for infants in early childhood (age group 2–5 years) strongly declines, significant between-group differences remain. VLBW infants still spend more than twice as many days hospitalized compared to NBW infants. In particular, we find that VLBW infants in early childhood are more likely to suffer from diseases of the respiratory system (335 percent), certain infectious and parasitic diseases (41 percent), and diseases of the nervous system (1,018 percent). A moderate increase in hospitalization time due to diseases of the nervous system and digestive system was also found for LBW infants in early childhood. However, because of the correlation between birth weight and mortality, particularly early in life, the decline of low birth weight coefficients from infancy to early childhood may be (at least to some extent) explained by sample selection. Therefore, the decrease in coefficients from infancy to early childhood does not necessarily reflect improved health among VLBW (LBW) newborns, but may also indicate the selection of healthier infants, since those with the worst health die. Following this argument, we ran a sensitivity check by restricting our sample to those individuals who survived the youngest age category and were therefore observed in early childhood. The sensitivity check shows that the effects on hospitalization time decrease by three days for VLBW infants and 0.2 days for LBW infants in their first year of life. This indicates that the effects are not mainly driven by selection.

Cost-increasing effects also occur in the outpatient sector. As shown in Table 3, health expenditures on VLBW (LBW) babies in their first year of life are €412 (€129) higher than those on their NBW counterparts. These figures represent elevations of 181 percent (57 percent). More than 80 percent of these effects are attributed to an increase in consumption of medical drugs. The disaggregated analysis of drug intake in Table 5[28] shows that these effects are mainly driven by anti-infectives, which contribute about 90 percent of the aggregate between-group effects on medical drug consumption. VLBW (LBW) newborns require €308.29 (€98.50) more worth of anti-infectives in their first year of life than do NBW babies. We also find significantly elevated expenditures on residual drugs among VLBW infants.[29] In early childhood, expenditures on anti-infectives are still higher among VLBW newborns; however, the effect is substantially smaller than that observed during the first year of life. Further cost-increasing effects among both lower-birth-weight groups on drugs affecting the alimentary tract and metabolism indicate that the lower-birth-weight groups have increased rates of metabolic disorders in early childhood.

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[28] For a limited number of drugs, the data do not contain information on the ATC codes. These drugs are included in the residual category.

[29] The counterintuitive decrease in expenditures on musculoskeletal drugs is quantitatively small.

Significant aggregate effects on medical attendance during infancy can only be discerned for LBW babies, whose expenditures on visits to resident doctors are €20.51 (10 percent) higher than those for NBW children. This effect is maintained during LBW babies' early childhoods. Whereas LBW infants utilize the services of resident doctors more often, VLBW babies mainly receive inpatient services throughout their early lives. The disaggregated analysis shows that the parents of LBW infants consult GPs more often in the first year of their infants' lives, whereas the significant effect among the 2–5-year age group is mainly driven by expenditures at disabled centers and on pediatric services. The significant impact of birth weight on the utilization of disabled centers may indicate that children born at LBW are at a higher risk of suffering from severe physical and/or psychic impairments. Finally, LBW children receive more diagnostic services (radiological and laboratory examinations) during early childhood than do NBW children.

Although we do not identify an aggregate effect on expenditures on doctor visits among VLBW infants between 2–5 years of age, this group of infants spends €13 (22 percent) more on the services of pediatricians than do NBW infants during early childhood (see Table 6). We interpret this as evidence that pediatrician services of resident doctors substitute for step-by-step inpatient treatment as newborns age. An alternative explanation is that the parents of VLBW infants see their pediatricians more often for regular health check-ups than do parents of NBW children.

3.2 Compulsory schooling

The most striking result of our analysis of children born with LBW and VLBW during the age of compulsory schooling is the shift of health problems towards mental illness and difficulties with concentration. For both lower-birth-weight groups, we still find that hospitalization is significantly increased in this age category. VLBW and LBW newborns spend 56 percent and 39 percent more days hospitalized than do their NBW counterparts in the same age group. The increase in the number of days spent hospitalized among VLBW children is solely driven by diseases of the nervous system. The patients are particularly likely to suffer from epilepsy (or epileptic syndrome), facial palsy, and several forms of migraine and tension headaches. The most frequent treatments they receive are magnetic resonance tomography, intensive epilepsy monitoring, physiotherapy, and logopedic and phoniatric therapy. Mental and behavioral disorders are quantitatively even more important for the LBW group. Days of hospitalization due to adjustment disorders, hospitalism, attention deficit disorders, hyperactivity syndrome, or other syndromes of social behavior are 140 percent higher than those for NBW school-age children. Consequently, these children receive significantly more day-clinic treatment in psychiatry, ergo- and physiotherapy, logopedic and phoniatric therapy, and stationary psychotherapy. Finally, we find that LBW children are more likely to contract diseases of the eye and adnexa but are less likely to be diagnosed with neoplasms or to be hospitalized because of injury, poisoning, and certain other consequences of external causes.

Whereas the increase in outpatient expenditures during compulsory schooling is moderate for LBW children (€15.62 or 8 percent), VLBW children spend €131.16 (67 percent) more on outpatient care in this period of life. In contrast to infancy, these cost-increasing effects are predominantly driven by more-frequent utilization of services provided by resident doctors. As shown in Table 6, the overwhelming majority of this increase is attributed to greater use of disabled centers and therapists. VLBW infants spend more on orthopedic services, physiotherapy, and hippotherapy that are provided either by disabled centers (€37.45; 937 percent) or by resident doctors (€31.82; 524 percent).[30] Though these expenses are lower in absolute terms among school-age children born with LBW, these children also require more services provided by disabled centers (161 percent) and speech therapists (56 percent) than do NBW children.

For school-age children born with VLBW, we also find significant cost-increasing effects for medical drugs. The additional €36.59 spent on medication by these children represents an increase of 114 percent. The aforementioned increase in days spent hospitalized for diseases of the nervous system is accompanied by higher consumption of drugs affecting the nervous system. Compared to NBW school-age children, VLBW infants of the same age spend €11.16 (336 percent) more on antiepileptics used in the treatment of epileptic seizures and bipolar disorder, psychoanaleptics (antidepressants, psychostimulants, etc.), and psycholeptics that produce calming effects on the patient. Significantly elevated intake of anti-infectives can still be found among children born with VLBW at this age; however, the effect size of €1.72 is substantially lower than that during infancy and early childhood. Finally, we find a significant and quantitatively important increase in expenditures on the residual drug category.

3.3 Adolescence and early adulthood

For the oldest individuals in our empirical analysis (aged 15–21 years) who were born at LBW, we find increased levels of both hospitalization (0.36 days; 49 percent) and drug expenditures (€10.33; 28 percent). The effects on days of hospitalization for LBW teenagers can be attributed to diseases of the respiratory system (see Table 4), whereas the only significantly increased category of medical drugs is those affecting the alimentary tract and metabolism, the expenditures on which increase by 80 percent in comparison to youths and young adults born with NBW. Surprisingly, for people in this age group born with VLBW, we identify cost-decreasing effects for several categories of medical drugs. Young adults born with VLBW spend

[30] Another significant cost increase for VLBW newborns was identified for pulmonology services.

less on anti-infectives (€3.03 or 36 percent), drugs for the genitourinary system (€0.46 or 96 percent), and the residual drug category (€8.81 or 68 percent). Although we do not find significant effects on medical attendance at the aggregate level, the disaggregated analysis shows an increase in expenditures at disabled centers (€4.81 or 676 percent) and on psychiatrists (€1.93 or 65 percent) among the LBW group. This is evidence that mental problems may persist until early adulthood among LBW children, though we do not observe an accompanying increase in their use of drugs affecting the nervous system. The standard errors during this age category rise considerably compared to the estimates during compulsory schooling; the lack of significant effects with respect to several outcomes among people in this age group born with VLBW may be attributable to the small sample size in this age group. As an alternative, we therefore combine both lower birth weight categories and generate a single group including all newborns with birth weights below 2,500 grams (see Tables A.1–A.4 in the appendix). These sensitivity checks suggest that youths and young adults who were born at weights below this threshold spend more days hospitalized because of diseases of the nervous system, spend more on outpatient psychiatric health services, and consume more drugs affecting the nervous system. Thus, these teenagers are still at higher risk for mental health problems.

4. Interpretation of results and concluding remarks

As expected, our analysis reveals that the largest effects of LBW and VLBW on health care utilization occur in the first year of life, with particularly pronounced impacts on the number of days spent hospitalized and the consumption of medical drugs. The increased intake of medical drugs is predominantly driven by anti-infectives, an effect explained by the fact that the immune systems of these newborns are not yet fully developed (Saari, 2003). Consequently, the administration of these drugs prevents those infants from contracting infectious diseases. Although the effects of birth weight on aggregate outcomes decline with age, suggesting that children of lower birth weights catch up to others over time, some differences persist. The disaggregated analyses suggest that LBW mainly affects physical health in infancy and early childhood. During compulsory schooling, we find the first evidence that the cognitive development of those children may be retarded. This conclusion is supported by four facts: (i) LBW children are more likely to be hospitalized for mental and behavioral disorders, (ii) their intake of drugs affecting the nervous system is substantially elevated, (iii) these children have a higher rate of treatment by speech therapists, and (iv) VLBW children receive more ergo- and hippotherapy. Drugs affecting the nervous system include preparations including the active ingredient methylphenidate (e.g., Ritalin). This suggests that children who consume this medication are more likely to suffer from mental disorders such as attention deficit hyperactivity syndrome (ADHS) that become noticeable when they enroll in school. This result is in line with the findings of Currie et al. (2010) and Linnet et al. (2006), who show that premature or LBW babies are at much higher risk of contracting ADHS. Nevertheless, we do not find significant effects regarding utilization of psychiatric services during compulsory schooling. This indicates that the majority of this category of drugs may be consumed without adequate medical care provided by psychiatric specialists.[31] Together with the fact that we do observe cost-increasing effects for psychiatric services in adolescence, we conclude that LBW predominantly affects mental health in the long and medium terms. However, their increased consumption of drugs affecting the alimentary tract and metabolism and their increased hospitalization rates for diseases of the respiratory system suggest that children of lower birth weight also have a higher risk of suffering from physical health maladies in adolescence and early adulthood.

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[31] In fact, more than two-thirds of total psychiatric medication in Austria is prescribed by general practitioners and not by psychiatrists (http://www.hauptverband.at/portal27/portal/hvbportal/channel_content/cmsWindow?action=2&p_menuid=73011&p_tabid=2&p_pubid=648931, Accessed: April 16, 2012).

The strong effects of LBW and VLBW during the first year of life and their reduction in size with age is compatible with the view that parents of children born at LBW and VLBW undertake health-improving medical investments that mitigate the negative consequences of the poor initial health endowments of their newborns. This analysis reveals that almost all differences in physical health between individuals born with less than 2,500 grams and their NBW counterparts disappear by early adulthood.[32] On the contrary, we provide evidence that differences in terms of diseases of the nervous system and the associated medical services and medication intake persist until early adulthood. From a policy perspective, the best solution would be to prevent LBW and particularly VLBW. To that end, further efforts in counseling for expectant mothers on the determinants and risk factors of VLBW and LBW may offer a promising avenue for reduction in its incidence. Although the behavior of the mother strongly influences the health of her children, environmental factors also affect conditions in utero. Since smoking is one of the most important amendable risk factors for VLBW and LBW, public smoking bans that aim to reduce exposure to secondhand smoke are of particular importance.

In case it is not possible to prevent VLBW and LBW entirely, access to and uptake of necessary medical treatments needs to be guaranteed in order to mitigate the negative consequences of VLBW and LBW. Nevertheless, in addition to the requirement of access to health services, children can receive appropriate treatment only if their health conditions are correctly diagnosed. Parents, however, might not properly interpret certain behaviors and symptoms shown by their children that indicate health problems. Therefore, a postnatal screening program especially tailored to VLBW and LBW children may represent an effective way to identify children who need further interventions. The benefits of medical and therapeutic interventions are expected to be large if they are delivered early in life. For instance, our results show that the consumption of services addressing problems of cognitive development increases during compulsory schooling. We hypothesize that the VLBW and LBW newborns' latent deficiencies in cognitive skills become visible only when they have to cope with the demands of school. The starting position of these children could be improved if they receive treatments (e.g., logopedic services) before school enrollment. Therefore, we expect screening programs of this kind to mitigate the consequences of negative conditions during pregnancy.

Finally, from a methodological perspective, Black et al. (2007) show that the bias in their OLS estimates of adult outcomes in terms of height, IQ, earnings, and education is much smaller than that for short-term outcomes. This can be explained by the fact that omitted variables (e.g., the smoking behavior of mothers) are more strongly correlated with short- than with long-term

[32] This analysis does not allow for judgment of potential long-term health effects that stay latent until later in adulthood, as discussed by Currie and Almond (2011). For a review of the intergenerational effects of fetal programming with respect to cardiovascular risk, see Drake and Walker (2004).

outcomes. Accordingly, we also find that the bias between the OLS and fixed-effects results decreases with age. Our results demonstrate that the bias decreases starting in the second year of life, not just during adulthood. Omitted variables such as maternal smoking behavior seem to affect the children strongly in utero, but their negative consequences may diminish early in life, as (unobserved) maternal characteristics become less important as the children age.

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7. Figures and Tables

Figure 1: Birth weight over time in Austria, 1971–2007

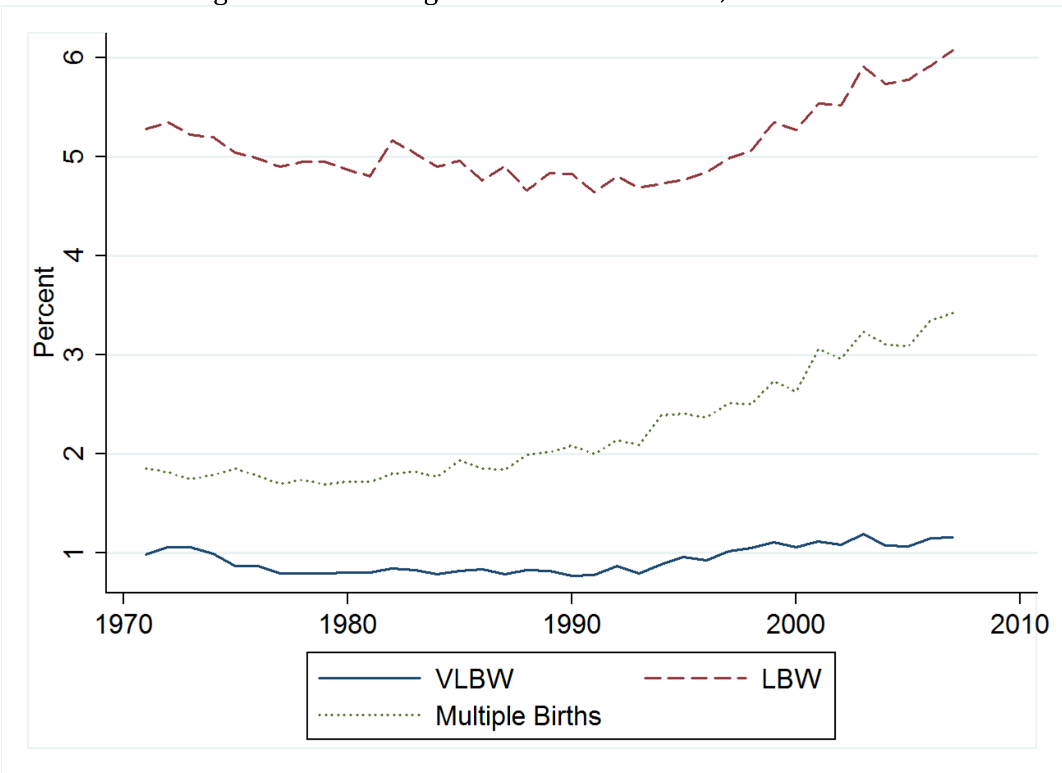

Table 1: Means and standard deviations of outcomes by birth weight category and age group[a]

	Normal birth weight (NBW)				Low birth weight (LBW)				Very low birth weight (VLBW)			
Age in years	0–1	2–5	6–14	15–21	0–1	2–5	6–14	15–21	0–1	2–5	6–14	15–21
Days of hospitalization	1.21 (4.41)	0.54 (3.08)	0.44 (4.88)	0.73 (4.94)	6.43 (12.07)	0.81 (3.82)	0.67 (5.94)	0.99 (6.17)	26.19 (35.80)	1.21 (4.06)	0.72 (3.43)	1.19 (5.87)
Outpatient expenditures	227.75 (161.71)	198.97 (206.02)	194.96 (284.85)	184.41 (241.81)	320.82 (457.60)	233.75 (290.41)	219.19 (327.72)	202.38 (292.17)	1173.76 (1263.94)	289.123 (485.01)	319.83 (506.29)	218.17 (369.03)
Medical attendance	202.37 (127.43)	167.89 (173.64)	162.94 (238.02)	147.56 (178.55)	232.56 (188.59)	191.98 (239.20)	180.64 (280.07)	158.86 (196.71)	207.03 (175.48)	208.39 (333.41)	256.07 (430.15)	176.83 (274.54)
Medical drugs taken	25.38 (73.60)	31.09 (79.17)	32.01 (124.51)	36.85 (129.92)	88.25 (392.48)	41.77 (136.65)	38.55 (134.40)	43.52 (182.33)	966.73 (1225.01)	80.73 (289.65)	63.75 (223.12)	41.34 (173.87)
Observations	18,579	70,328	227,548	134,739	854	2,957	7,926	4,856	119	462	1,136	425

[a] This table provides the annual means and the standard deviations (in parentheses) of outcome variables by birth weight category and age group. The figures represent an unbalanced panel data set that covers the period from 2005 through 2009. Outpatient expenditures and expenditures on medical attendance and medical drugs are measured in 2009 euros per year. Note that insurants contribute to up to five observations and may be represented in up to three age groups.

Table 2: OLS estimation results for main outcomes[a]

	Very low birth weight (VLBW)				Low birth weight (LBW)			
Age in years	0–1	2–5	6–14	15–21	0–1	2–5	6–14	15–21
Days of hospitalization	24.98***	0.69***	0.30***	0.47	5.23***	0.29***	0.24***	0.25**
	(2.62)	(0.22)	(0.11)	(0.30)	(0.46)	(0.08)	(0.09)	(0.11)
NBW mean	1.21	0.54	0.44	0.73	1.21	0.54	0.44	0.73
Outpatient expenditures	957.18***	91.86***	119.84***	32.56	102.39***	34.65***	21.77***	14.23**
	(141.09)	(32.83)	(25.49)	(29.39)	(18.96)	(7.71)	(5.87)	(6.64)
NBW mean	227.75	198.98	194.95	184.41	227.75	198.98	194.95	184.41
Medical attendance	11.55	41.51*	88.31***	28.25	34.52***	23.58***	15.43***	7.90**
	(17.62)	(21.77)	(22.24)	(22.70)	(7.41)	(6.25)	(4.86)	(3.94)
NBW mean	202.37	167.89	162.94	147.56	202.37	167.89	162.94	147.56
Medical drugs taken	945.63***	50.35***	31.54***	4.31	67.86***	11.07***	6.34**	6.33
	(137.54)	(18.42)	(9.95)	(11.94)	(16.12)	(3.59)	(2.51)	(4.54)
NBW mean	25.38	31.09	32.01	36.85	25.38	31.09	32.01	36.85

[a] This table summarizes ordinary least squares (OLS) estimation results for the effects of VLBW and LBW on four different health outcomes for different age groups. Each entry reflects a separate estimation. Outpatient expenditures and expenditures on medical attendance and medical drugs are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

Table 3: FE estimation results for main outcomes[a]

	Very low birth weight (VLBW)				Low birth weight (LBW)			
Age in years	0–1	2–5	6–14	15–21	0–1	2–5	6–14	15–21
Days of hospitalization	14.92***	0.58**	0.25*	-0.12	4.30***	0.20*	0.17***	0.36*
	(4.89)	(0.26)	(0.14)	(1.00)	(1.30)	(0.11)	(0.06)	(0.21)
NBW mean	1.21	0.54	0.44	0.73	1.21	0.54	0.44	0.73
Outpatient expenditures	412.39**	72.13*	131.16***	-10.60	129.41***	41.73***	15.62*	14.49
	(185.05)	(37.79)	(37.49)	(49.85)	(46.03)	(11.94)	(8.22)	(9.18)
NBW mean	227.75	198.98	194.95	184.41	227.75	198.98	194.95	184.41
Medical attendance	79.23	48.74	94.57***	-9.02	20.51**	28.44***	13.47**	4.16
	(63.26)	(32.12)	(33.48)	(42.01)	(9.31)	(9.88)	(6.80)	(5.65)
NBW mean	202.37	167.89	162.94	147.56	202.37	167.89	162.94	147.56
Medical drugs taken	333.17*	23.39**	36.59**	-1.59	108.89**	13.30**	2.15	10.33*
	(177.51)	(11.29)	(14.33)	(18.88)	(44.90)	(5.92)	(4.04)	(6.22)
NBW mean	25.38	31.09	32.01	36.85	25.38	31.09	32.01	36.85

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effects of VLBW and LBW on four different health outcomes for different age groups. Each entry reflects a separate estimation. Outpatient expenditures and expenditures on medical attendance and medical drugs are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

Table 4: FE estimation results for days of hospitalization by diagnosis[a]

	Very low birth weight (VLBW)				Low birth weight (LBW)			
Age in years	0-1	2-5	6-14	15-21	0-1	2-5	6-14	15-21
Certain infectious and	1.05	0.22**	0.06	-0.01	0.13	-0.01	0.01	-0.03
parasitic diseases	(0.94)	(0.09)	(0.04)	(0.01)	(0.17)	(0.03)	(0.01)	(0.03)
NBW mean	0.12	0.06	0.02	0.02	0.12	0.06	0.02	0.02
Neoplasms	0.00	0.00	-0.31	0.04	0.00	0.01	-0.02*	-0.00
	(0.00)	(0.01)	(0.28)	(0.05)	(0.00)	(0.01)	(0.01)	(0.00)
NBW mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mental and behavioural	-0.00	-0.07	0.11	-0.79	0.00	0.03	0.16**	0.68
disorders	(0.00)	(0.08)	(0.08)	(1.29)	(0.00)	(0.03)	(0.08)	(0.42)
NBW mean	0.00	0.03	0.11	0.17	0.00	0.03	0.11	0.17
Diseases of the	0.42**	0.18**	0.303**	0.46	0.05	0.07**	0.07**	0.10
nervous system	(0.21)	(0.09)	(0.13)	(0.33)	(0.13)	(0.03)	(0.03)	(0.08)
NBW mean	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Diseases of the eye and adnexa	-0.27	-0.11**	-0.05	0.08	0.31	-0.03	0.03***	0.04
	(0.51)	(0.05)	(0.07)	(0.08)	(0.31)	(0.04)	(0.01)	(0.05)
NBW mean	0.03	0.03	0.01	0.02	0.03	0.03	0.01	0.02
Diseases of the respiratory	1.17	0.54*	0.00	-0.02	1.57**	0.23	0.01	0.07*
system	(0.83)	(0.29)	(0.05)	(0.05)	(0.72)	(0.15)	(0.01)	(0.04)
NBW mean	0.27	0.16	0.05	0.05	0.27	0.16	0.05	0.05
Diseases of the	-0.31	0.05	0.03	0.12	0.04	0.02*	-0.02	-0.00
digestive system	(0.74)	(0.04)	(0.03)	(0.11)	(0.12)	(0.01)	(0.02)	(0.03)
NBW mean	0.05	0.04	0.05	0.07	0.05	0.04	0.05	0.07
Diseases of the	-0.48	-0.04	0.01	-0.17**	-0.02	-0.03	-0.00	-0.01
genitourinary system	(0.45)	(0.04)	(0.02)	(0.07)	(0.11)	(0.02)	(0.01)	(0.03)
NBW mean	0.06	0.03	0.02	0.03	0.06	0.03	0.02	0.03
Certain conditions originating	10.37**	0.02	0.00	0.00	1.32*	-0.01	-0.00	0.00
in the perinatal period	(4.41)	(0.02)	(0.00)	(0.00)	(0.77)	(0.01)	(0.00)	(0.00)
NBW mean	0.24	0.00	0.00	0.00	0.24	0.00	0.00	0.00
Injury, poisoning and certain other	0.11	0.06	-0.01	-0.05	0.12	0.01	-0.02*	-0.06
consequences of external causes	(0.12)	(0.07)	(0.02)	(0.04)	(0.12)	(0.02)	(0.01)	(0.16)
NBW mean	0.07	0.05	0.04	0.12	0.07	0.05	0.04	0.12

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effect of VLBW and LBW on days of hospitalization according to admission diagnoses (ICD-10 classification) for different age groups. Each entry reflects a separate estimation. Standard errors (in parenthesis) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent level, 5-percent level, and 1-percent level, respectively. The estimations also control for the age of the child and the mother, sex of the child, the number of siblings, birth order, and year fixed-effects.

Table 5: FE estimation results for medical attendance by provider category[a]

	Very low birth weight (VLBW)				Low birth weight (LBW)			
Age in years	0–1	2–5	6–14	15–21	0–1	2–5	6–14	15–21
GP	6.61	-5.59	2.12	-11.12	8.60*	1.30	0.31	0.07
	(7.91)	(4.31)	(2.27)	(7.18)	(4.75)	(1.58)	(0.84)	(1.51)
NBW mean	66.80	59.02	37.56	47.50	66.80	59.02	37.56	47.50
Pediatrician	-0.37	12.99***	2.72	0.37	9.20	4.16**	-0.15	0.58
	(20.26)	(5.03)	(1.72)	(0.34)	(7.94)	(1.77)	(0.60)	(0.37)
NBW mean	118.12	50.23	9.63	1.15	118.12	50.23	9.63	1.15
Pulmonologist	0.13	1.08	2.32*	-0.93	0.19	-0.01	-0.25	-0.21
	(0.17)	(1.04)	(1.26)	(1.36)	(0.16)	(0.45)	(0.43)	(0.52)
NBW mean	0.28	1.48	2.81	2.83	0.28	1.48	2.81	2.83
Psychiatrist	-0.00	0.91	1.29	-0.13	-0.01	-0.38	0.20	1.93**
	(0.01)	(0.89)	(1.21)	(1.29)	(0.01)	(0.37)	(0.47)	(0.92)
NBW mean	0.04	0.51	1.98	2.98	0.04	0.51	1.98	2.98
Speech therapist	0.04	1.70	2.65	-0.45	0.03	4.18	4.16*	-0.41*
	(0.06)	(7.79)	(3.81)	(0.38)	(0.04)	(4.32)	(2.24)	(0.25)
NBW mean	0.11	11.51	7.46	0.38	0.11	11.51	7.46	0.38
Disabled center	23.27	21.10	37.45*	22.14	2.56	11.61**	6.54*	4.81***
	(21.91)	(15.57)	(21.89)	(14.79)	(2.52)	(4.71)	(3.49)	(1.85)
NBW mean	0.60	3.68	4.00	0.71	0.60	3.68	4.00	0.71
Therapy[b]	54.56	16.57	31.82**	22.71	0.30	5.46	3.79	2.33
	(45.29)	(11.66)	(12.67)	(14.86)	(4.40)	(3.42)	(2.60)	(1.61)
NBW mean	6.85	4.82	6.07	4.80	6.85	4.82	6.07	4.80
Diagnostics	-2.38	0.07	0.23	-4.77	-0.47	1.42***	-0.62	-0.07
	(2.39)	(1.39)	(0.99)	(3.18)	(2.61)	(0.53)	(0.42)	(0.95)
NBW mean	3.39	3.05	4.74	10.51	3.39	3.05	4.74	10.51
Residual	-6.11	-0.87	13.39	-37.63	0.06	0.45	-0.65	-4.97
category	(5.62)	(6.62)	(9.86)	(28.16)	(1.94)	(2.04)	(3.73)	(3.54)
NBW mean	5.66	33.26	88.28	76.22	5.66	33.26	88.28	76.22

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effects of VLBW and LBW on expenditures on subcategories of medical attendance. Each entry reflects a separate estimation. Expenditures are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

[b] Orthopedic services, physiotherapy and hippotherapy

Table 6: FE estimation results for medical drugs taken by category[a]

	Very low birth weight (VLBW)				Low birth weight (LBW)			
Age in years	0–1	2–5	6–14	15–21	0–1	2–5	6–14	15–21
Alimentary tract	2.49	3.18*	0.11	0.33	-0.47	1.08**	0.40	2.82*
and metabolism	(2.82)	(1.81)	(0.38)	(0.45)	(0.82)	(0.51)	(1.34)	(1.66)
NBW mean	2.62	1.90	1.73	3.52	2.62	1.90	1.73	3.52
Genitourinary	-0.03	0.20	0.25	-0.46*	0.01	0.04	0.40*	0.02
system	(0.08)	(0.37)	(0.78)	(0.23)	(0.08)	(0.05)	(0.22)	(0.08)
NBW mean	0.08	0.15	0.20	0.48	0.08	0.15	0.20	0.48
Anti-infectives								
for	308.29*	14.82*	1.72*	-3.03**	98.50**	7.46	0.13	0.41
systemic use	(175.94)	(7.65)	(1.02)	(1.34)	(43.63)	(5.22)	(0.34)	(0.63)
NBW mean	8.30	12.10	7.50	8.34	8.30	12.10	7.50	8.34
Musculoskeletal	-0.35*	-0.20	0.27	-0.35	-0.14*	0.04	0.07	0.49
system	(0.20)	(0.13)	(0.28)	(0.33)	(0.08)	(0.09)	(0.07)	(0.60)
NBW mean	0.20	0.47	0.74	1.41	0.20	0.47	0.74	1.41
Nervous	2.39	7.56	11.16**	24.52	2.86	0.73	1.74	5.57
system	(2.32)	(5.73)	(5.39)	(15.41)	(3.07)	(0.47)	(1.65)	(3.74)
NBW mean	0.44	0.67	3.32	5.09	0.44	0.67	3.32	5.09
Respiratory	3.25	-0.57	3.35	-13.80	-1.08	2.16	-0.08	0.40
system	(3.40)	(4.43)	(4.54)	(9.94)	(2.08)	(1.46)	(1.27)	(1.33)
NBW mean	2.90	6.04	7.00	5.02	2.90	6.04	7.00	5.02
Residual	17.13**	-1.60	20.24*	-8.81**	9.22	1.78	-0.51	0.62
category	(7.56)	(3.21)	(12.19)	(3.68)	(6.88)	(1.71)	(2.97)	(2.22)
NBW mean	10.85	9.77	11.52	12.99	10.85	9.77	11.52	12.99

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effects of VLBW and LBW on expenditures on subcategories of medical drugs (ATC classification). Each entry reflects a separate estimation. Expenditures are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

Appendix

Table A1: FE estimation results for main outcomes (robustness check)[a]

	Low birth weight			
Age in years	0–1	2–5	6–14	15–21
Days of hospitalization	5.62***	0.48**	0.24**	0.73
	(1.83)	(0.21)	(0.12)	(0.48)
NBW mean	1.21	0.54	0.44	0.73
Outpatient expenditures	189.38***	51.72***	30.48***	19.79*
	(66.89)	(14.21)	(9.57)	(10.90)
NBW mean	227.75	198.98	194.95	184.41
Medical attendance	33.62***	33.37***	24.55***	5.39
	(11.96)	(10.89)	(8.01)	(6.83)
NBW mean	202.37	167.89	162.94	147.56
Medical drugs taken	155.76**	18.35**	5.93	14.40**
	(64.30)	(8.10)	(4.45)	(7.24)
NBW mean	25.38	31.09	32.01	36.85

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effect of low birth weight (below 2500 grams) on four different health outcomes for different age groups. Each entry reflects a separate estimation. Outpatient expenditures and expenditures on medical attendance and medical drugs are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

Table A2: FE estimation results for days of hospitalization by diagnosis (robustness check)[a]

	Low birth weight			
Age in years	0–1	2–5	6–14	15–21
Certain infectious and parasitic diseases	0.20	0.02	0.02*	-0.03
	(0.22)	(0.03)	(0.01)	(0.03)
NBW mean	0.12	0.06	0.02	0.02
Neoplasms	0.00	0.01	-0.06	0.00
	(0.00)	(0.01)	(0.04)	(0.01)
NBW mean	0.01	0.01	0.01	0.01
Mental and behavioral disorders	0.00	0.01	0.16**	0.57
	(0.00)	(0.03)	(0.07)	(0.41)
NBW mean	0.00	0.03	0.11	0.17
Diseases of the nervous system	0.08	0.08***	0.10***	0.13*
	(0.13)	(0.03)	(0.04)	(0.08)
NBW mean	0.02	0.02	0.02	0.02
Diseases of the eye and adnexa	0.27	-0.04	0.02**	0.04
	(0.31)	(0.04)	(0.01)	(0.04)
NBW mean	0.03	0.03	0.01	0.02
Diseases of the respiratory system	1.54**	0.27*	0.01	0.07*
	(0.70)	(0.15)	(0.01)	(0.04)
NBW mean	0.27	0.16	0.05	0.05
Diseases of the digestive system	0.01	0.03**	-0.01	0.01
	(0.12)	(0.01)	(0.02)	(0.03)
NBW mean	0.05	0.04	0.05	0.07
Diseases of the genitourinary system	-0.06	-0.04	-0.00	-0.02
	(0.10)	(0.02)	(0.01)	(0.03)
NBW mean	0.06	0.03	0.02	0.03
Certain conditions originating in the perinatal period	2.01**	-0.00	-0.00	-0.00
	(0.96)	(0.01)	(0.00)	(0.00)
NBW mean	0.24	0.00	0.00	0.00
Injury, poisoning, and certain other consequences with external causes	0.12	0.02	-0.02*	-0.06
	(0.12)	(0.02)	(0.01)	(0.15)
NBW mean	0.07	0.05	0.04	0.12

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effects of low birth weight (below 2,500 grams) on the number of days of hospitalization according to admission diagnoses (ICD-10 classification) for different age groups. Each entry reflects a separate estimation. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

Table A3: FE estimation results for medical attendance by provider category (robustness check)[a]

	Low birth weight			
Age in years	0–1	2–5	6–14	15–21
GP	9.19*	0.85	0.63	-0.20
	(4.78)	(1.69)	(0.90)	(1.60)
NBW mean	66.80	59.02	37.56	47.50
Pediatrician	17.54*	5.82***	0.17	0.64*
	(10.40)	(1.86)	(0.60)	(0.37)
NBW mean	118.12	50.23	9.63	1.15
Pulmonologist	0.25	0.21	-0.09	-0.39
	(0.21)	(0.44)	(0.44)	(0.50)
NBW mean	0.28	1.48	2.81	2.83
Psychiatrist	-0.01	-0.37	0.06	2.15**
	(0.01)	(0.46)	(0.54)	(0.92)
NBW mean	0.04	0.51	1.98	2.98
Speech therapist	0.07	4.41	3.93*	-0.41*
	(0.10)	(4.27)	(2.09)	(0.22)
NBW mean	0.11	11.51	7.46	0.38
Disabled center	4.41	13.58**	11.28**	6.39***
	(4.47)	(5.43)	(4.59)	(2.33)
NBW mean	0.60	3.68	4.00	0.71
Therapy [b]	4.34	7.36**	7.87**	4.35**
	(4.19)	(3.75)	(3.08)	(2.14)
NBW mean	6.85	4.82	6.07	4.80
Diagnostics	-1.71	1.25**	-0.64	-0.41
	(2.82)	(0.53)	(0.45)	(0.96)
NBW mean	3.39	3.05	4.74	10.51
Residual	-0.67	-0.08	1.15	-6.93
category	(2.41)	(2.08)	(3.68)	(4.48)
NBW mean	5.66	33.26	88.28	76.22

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effects of low birth weight (below 2,500 grams) on expenditures on subcategories of medical attendance. Each entry reflects a separate estimation. Expenditures are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.

[b] Orthopedic services, physiotherapy and hippotherapy

Table A4: FE estimation results for medical drugs taken by category (robustness check)[a]

	Low birth weight			
Age in years	0–1	2–5	6–14	15–21
Alimentary tract and metabolism	0.09	1.53***	0.24	3.01*
	(1.14)	(0.57)	(1.21)	(1.72)
NBW mean	2.62	1.90	1.73	3.52
Genitourinary system	-0.02	0.06	0.38	-0.04
	(0.10)	(0.07)	(0.27)	(0.08)
NBW mean	0.08	0.15	0.20	0.48
Anti-infectives for systemic use	139.65**	10.99	0.15	0.09
	(61.33)	(7.52)	(0.37)	(0.76)
NBW mean	8.30	12.10	7.50	8.34
Musculoskeletal system	-0.11	0.02	0.12	0.32
	(0.10)	(0.08)	(0.08)	(0.57)
NBW mean	0.20	0.47	0.74	1.41
Nervous system	3.64	1.60	3.92**	8.32*
	(3.73)	(0.99)	(1.95)	(4.26)
NBW mean	0.44	0.67	3.32	5.09
Respiratory system	-0.68	1.91	0.29	-0.36
	(1.88)	(1.33)	(1.26)	(1.23)
NBW mean	2.90	6.04	7.00	5.02
Residual category	13.19	2.24	0.84	3.05
	(8.11)	(1.89)	(3.39)	(3.15)
NBW mean	10.85	9.77	11.52	12.99

[a] This table summarizes sibling fixed-effects (FE) estimation results for the effects of low birth weight (below 2,500 grams) on expenditures on subcategories of medical drugs (ATC classification). Each entry reflects a separate estimation. Expenditures are measured in 2009 euros per year. Standard errors (in parentheses) are robust to clustering at the individual level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for the ages of the child and mother, sex of the child, number of siblings, birth order, and year fixed-effects.