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THE EFFECTIVENESS OF PRENATAL CARE IN A LOW INCOME POPULATION: A PANEL DATA APPROACH

Ana I. Balsa*
Universidad de Montevideo
Puntas de Santiago 1604
Montevideo, Uruguay

Patricia Triunfo
Universidad de la República
Constituyente 1502, 6º piso
Montevideo, Uruguay

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The Effectiveness of Prenatal Care in a Low Income Population: A Panel Data Approach

Ana I. Balsa [*]
Universidad de Montevideo
Puntas de Santiago 1604
Montevideo (11500), Uruguay

Patricia Triunfo
Universidad de la Republica
Constituyente 1502, 6to piso
Montevideo, Uruguay

Abstract

This paper analyzes the impact of prenatal care on the likelihood of low birth weight and prematurity using panel data on births taking place between 1995 and 2008 in the largest maternity ward in Uruguay. The use of difference-Generalized Method of Moments estimation addresses biases due to time invariant unobserved heterogeneity and feedback effects from prior pregnancies. Our estimates are larger than those usually found for developed countries: an adequate use of prenatal care - as defined by the Kessner criterion - decreases the probability of low birth weight by half and the likelihood of a pre-term birth by 70%. Even when imposing less stringent requirements on the total number of prenatal controls, the improvements over birth outcomes are considerable. In addition to indicating the crucial role of prenatal care in the birth outcomes of low-income populations, our analysis highlights the importance of using econometric techniques that use the full distribution of pregnancies to estimate the effectiveness of prenatal care.

Keywords: prenatal care, panel data, difference GMM, lowbirth weight, low SES populations

JEL Classifications: I12, J13, C14

[*] Corresponding author. E-mail: abalsa@um.edu.uy; Telephone: +(598) 2604 2544 ext. 651; Fax: +(598) 2604 2544 ext 602.

1. Introduction

Preterm birth and low birth weight (LBW)[1] are commonly used as proxies for infant health (McCormick, 1985; Institute of Medicine, 1985). LBW has been associated with increased morbidity and mortality both during childhood and adulthood. Petrou et al. (2000) show that preterm birth and low birth weight can result in substantial costs to the health care sector following the infant's initial discharge from the hospital. LBW has also been associated with lower educational attainment and decreased lifetime income (Boardman et al., 2002; Black et al., 2007), and has been underscored as an important mechanism for the intergenerational transmission of economic status (Currie and Madrian, 1999; Grossman, 2000; Case et al., 2004; Behrman and Rosenzweig, 2005; Currie and Moretti, 2005).

LBW is usually modeled as the result of a process of utility maximization, where the mother's utility is a function of the child's health, and inputs such as prenatal care, smoking, and the mother's health endowment are used to produce birth outcomes (Grossman, 2000).Understanding the impact of these inputs is key to minimizing the high burden that LBW imposes on society. Research has mainly focused on two types of determinants of infant health that can be altered through public policy: prenatal care and use of substances (alcohol, tobacco or other drugs) during pregnancy. Prenatal care has been encouraged in the medical community for its ability to identify mothers at risk of premature delivery or babies with intrauterine growth retardation (IUGR), enabling a variety of medical, nutritional, and educational interventions aimed at reducing poor birth outcomes, such as LBW.

The estimation of the relationship between prenatal care and birth outcomes is challenged by the inability to control for maternal characteristics associated with both the demand for prenatal care and the infant's health at birth. Without adequately controlling for health endowments, the mother's health habits, her propensity to embark on risky behaviors, or the extent to which the pregnancy is desired, an association between prenatal care and infant health cannot be regarded as causal. The economic literature in the past 15 years has been

[1] Birth weight below 2500 grams.

proactive at modeling the endogeneity between prenatal care and neonatal health outcomes. Most of these investigations have exploited the association between exogenous variations in health care coverage policies and prenatal care use by employing either reduced-form models or two-stages least squares (2SLS) techniques (Kaestner, 1999; Brien and Swann, 2001; Currie and Grogger, 2002; Figlio et al., 2009). A few authors have used 2SLS with alternative instruments such as input prices, the availability of prenatal clinics in the area, the number of previous children (Grossman and Joyce, 1990) or public transportation strikes in the county (Evans and Lien, 2005). Even when addressing endogeneity, the economic literature has been mixed regarding the effects of prenatal care on birth weight. The evidence is divided between those that find slight or no effects (Grossman and Joyce, 1990; Kaestner, 1999, Currie and Grogger, 2002; Kaestner and Lee, 2003) and those who find positive effects of significant magnitude (Rosenzweig and Schultz, 1983; Evans and Lien, 2005; Conway and Deb, 2005; Wehby et al., 2009; Figlio et al., 2009). This failure to find strong evidence together with other findings from clinical investigations (McDuffie et al., 1996; Clement et al., 1999; Villar et al., 2001) has led some researchers to question whether the benefits of prenatal care have been "oversold" (Misra and Guyer, 1998).

A recent critique posits that previous research has only been able to identify average effects that lose sight of the differential impact of prenatal care in different types of pregnancies. The results of randomized clinical trials, for example, are only valid externally for populations with low-risk pregnancies. And 2SLS estimate local effects that are valid for the population marginally affected by changes in the instrument. In addition, Conway and Deb (2005) argue that when the difference between risky and healthy pregnancies is not recognized in the estimation, 2SLS estimation produces bi-modal errors and leads to non-significant effects of prenatal care.

Another problem with the literature is that it is almost exclusively focused on developed countries. The effectiveness of prenatal care may be quite different in developing countries, where women are, in general, less informed about the health consequences of certain conditions and behaviors, and have lower resources to address nutritional and hygiene needs. The role of the health care provider, particularly in low income contexts, may be critical to promote healthy deliveries and decrease the incidence of low birth weight. In line with this argument, preliminary evidence for Uruguay shows that the transition from no prenatal controls to nine controls significantly increases the birth weight of the child (Jewell and Triunfo, 2006; Jewell et al., 2007). More recent research for Argentina provides evidence of strong effects of prenatal care, particularly in the lower quantiles of the birth weight distribution (Wehby et al., 2009).

This investigation analyzes the effectiveness of prenatal care in a low income population in Uruguay, South America. From a methodological point of view, it shifts the burden of proof from techniques that produce local average treatment effects to methods that use the whole distribution of pregnancies. Our estimation strategy exploits intra-mother variation in prenatal care for women who had at least two births between 1995 and 2008 in the main maternity ward in Montevideo, the Pereira Rossell Hospital. By using difference GMM, we address the problem of time-invariant unobserved heterogeneity and, at the same time, attack potential biases due to feedback effects from previous pregnancies into the current input choice.

Our analysis sheds new light on the effectiveness of prenatal care in developing countries. The evidence is very timely for Uruguay, given the recent efforts by the Ministry of Public Health (MPH) to improve the coverage of prenatal care in the country. Since 2010, the Uruguayan government rewards providers affiliated with the National Social Health Insurance with a performance payment for achieving a set of primary care goals. These goals include, among others, having 100% of the pregnant population initiate care during the first trimester and having each pregnant woman complete at least six prenatal controls by the time of delivery. While all health-care providers are, in principle, eligible to receive supplemental payments, the program is being effectively enforced with private providers only.[2] Our results have clear public policy connotations: if the State Health Services Administration in Uruguay, which offers health

[2] Uruguay has a mixed health insurance system. The population formally engaged in the labor market and their families are covered by a National Social Health Insurance that provides services either through private or public providers. Most beneficiaries are enrolled withprivate providers. The public provider, the State Health Services Administration (ASSE), covers low-income populations that are not formally inserted in the labor market. This population shows the lowest rates of initiation of care during the first trimester and the highest non-compliance with recommended standards of care.

services to low SES women, achieves the prenatal care goals proposed by the MPH, the rate of low birth weight in this population would drop by 30%. The effects would be even stronger if the goals were aimed at achieving nine rather than six controls in a full-term pregnancy.

2. Conceptual Framework and Methodology

The production of birth weight is usually modeled in economics as the result of a process of parental utility maximization. Parents' utility is a function of their children's well-being, which depends directly on the children's health. Conditional on genetic endowments and household resources, parents are indirect producers of children's health: they decide which inputs to invest in, in order to maximize their children's health status. These inputs include the use of prenatal care, use of substances during pregnancy, exercise and nutrition, among others (Grossman, 2000). As mentioned earlier, the analyst's inability to observe the full set of maternal preferences, resources, and information involved in the household production of health may lead to biases in the estimation. Unobserved characteristics such as the health endowment of the fetus and/or the mother, the mother's health habits, her propensity to embark on risky behavior, or the extent to which the pregnancy is desired, could bias the estimates if their influence is not taken into consideration.

In this paper, we address this endogeneity by using difference GMM techniques. Our methodology exploits the availability of longitudinal information for the same mother across several years. The underlying model is of the form:

$$Y_{ij}= a_0 + a_1\, CP_{ij}+ X_{ij}'\beta+ \alpha_i + \varepsilon_{ij}, \qquad (1)$$

where Y_{ij} reflects the outcome of mother i's pregnancy j (LBW or preterm birth), j denotes the birth order, CP_{ij} is an indicator of the adequacy of prenatal care, and X_{ij} includes other determinants of the newborn's health (such as age, education, mother's marital status, tobacco use, mother's Body Mass Index, history of past births, and quarter and year of pregnancy). The term α_i captures the time-invariant unobserved heterogeneity in i, namely, personality characteristics of the mother that affect her habits, her involvement in risky behavior, her health endowment, her knowledge about the benefits of prenatal care, her preferences, and so forth. Finally, ε_{ij} is an idiosyncratic error term independent of α_i and other explanatory variables.

A naïve estimate of a_1 resulting from the regression of the outcome variable Y_{ij} on the indicator of adequacy of prenatal care CP_{ij}, is potentially biased (even after adjusting for other controls X_{ij}) if it does not account for the unobserved heterogeneity component, α_i, which is associated both with the explanatory variable of interest and with the dependent variable. This has been a common estimation error in the biomedical literature, which has resulted in unreliable estimates of the effectiveness of prenatal care.

We begin our analysis by projecting deviations in neonatal outcomes on deviations in prenatal care that happen across the same mother's different pregnancies (adjusting for within variations in other characteristics). In order to eliminate the potential correlation between the mother-specific fixed effect α_i and inputs in the production function of child's health, the methodology requires transforming the data into within-mother deviations. We work with the first differences in our core model[3], and for sensitivity, we also re-estimate the models using the "within transformation" (fixed effects) and orthogonal deviations (Arellano and Bover 1995). Once the data are transformed, the model identifies the effect of interest, a_1, by getting rid of the idiosyncratic time invariant term α_i:

$$Y_{ij} - Y_{ij-1} = a_1(CP_{ij} - CP_{ij-1}) + a_2(X_{ij} - X_{ij-1}) + \varepsilon_{ij} - \varepsilon_{ij-1}. \qquad (2)$$

The nice feature of this method relative to 2SLS is that it estimates average global treatment effects. One of the problems with the extant literature on the effectiveness of prenatal care is that it tends to rely exclusively on the population of compliers, i.e., those that increase the use of prenatal care when confronted with an exogenous policy shock (an increase in healthcare coverage, for example). These local treatment effects may provide a distorted picture of the effectiveness of prenatal care if the impacts are heterogeneous across the different subpopulations. If policy changes do not modify, on the margin, the behavior of those most likely to benefit from prenatal care, the 2SLS estimates will underestimate its impact. Moreover, even if the group of compliers includes complicated and normal pregnancies, combining them in single 2SLS estimation may yield bimodal residuals that will result in insignificant estimates. Using a finite mixture model, Conway and Deb (2005) find estimates of prenatal care that have

[3] This transformation involves subtracting the observation in *j-1* from that in *j* for the same mother.

a consistent, substantial effect on normal pregnancies. Using Monte Carlo experiment, they show that ignoring even a small proportion of complicated pregnancies can cause prenatal care to appear as insignificant.

The differencing technique proposed in (2) may fail to produce consistent estimates in two scenarios: a) if there are time-variant shocks associated with both the use of prenatal inputs and birth outcomes; and b) if there is serial correlation in the decision to use prenatal care. The former would include any changes in preferences, resources, or information between deliveries that are not captured by the time-variant adjustors used in the analysis. For example, such would be the case if an unobserved negative shock on the fetus' health endowment decreased the expected prenatal outcomes and led the mother to increase the use of prenatal care. Or, if the government implemented an information campaign that encouraged the use of prenatal care as well as other changes in maternal behavior. The second problem would occur if past shocks affected the contemporaneous demand for inputs. For example, a mother may react to an adverse shock to a previous pregnancy (a pregnancy that ended in a pre-term birth or that had some risk of miscarriage) by increasing the demand for inputs or for quality inputs in the current pregnancy (feedback effect). In either of these two cases, working with deviations from past values will not lead to consistent estimates of the coefficients of interest.

Abrevaya (2006) recognized these problems while analyzing the effect of tobacco on birth outcomes, and suggested using a difference-GMM model with the level of the explanatory variable lagged two periods as the instrument for the first difference. We initially attempted to take this avenue, but as in Abrevaya (2006), the instruments were too imprecise. Thus, in this paper, we proceed to address the second problem formally, and discuss later why we think the problem of time variant unobserved heterogeneity may be, at most, moderate.

To see the serial correlation problem formally, suppose that the model is as in (1), but past shocks pre-determine the level of inputs in t:

$$E(CP_{ij},\varepsilon_{ij-1}) \neq 0 \qquad (3)$$

Under this assumption, the first difference transformation in (2) generates an endogenous relationship between the deviations in prenatal care and the differenced error term.

We propose addressing this feedback problem by running GMM on first-differences (difference-GMM), and by using a one-period (and eventually deeper) lag(s) of the predetermined variable as "GMM-style" instrument(s) of the contemporary deviations in that variable (Holtz-Eakin et al., 1988; Roodman, 2006). Specifically, we use the level of prenatal care in pregnancy j-1, and deeper lags when available, as instruments for the difference in prenatal care use between pregnancies j and j-1.[4]

Our first specification assumes no feedback effects: it relies on the assumption that past shocks are orthogonal to the current demand for prenatal inputs. Next, we allow for feedback effects to play a role and estimate the model using the lagged levels of prenatal care as instruments of the first difference in prenatal care. All the regressions control for the year of birth dummies and compute robust standard errors that are clustered at the mother's level. We run two specifications of the model: one without adjusting for the duration of the pregnancy, and the other controlling for the number of weeks of gestation at delivery because the effects of prenatal care on birth weight can occur through the probability of delivering at full-term. In the GMM specification, we instrument deviations in gestational weeks with two lags of the number of gestational weeks in levels.

3. Data

We analyze births registered in the Perinatal Information System (PIS) of the Pereira Rossell Hospital between 1995 and 2008. The Pereira Rossell is a public teaching hospital that depends on the University of the Republic and on the State Health Services Administration (ASSE). The hospital is a reference center for acute care of mother and child for the whole country, concentrating 50% of the births that take place in public wards in Montevideo, 33% of all births in Montevideo, and 15% of births nationwide.

The PIS was developed in 1983 by the Center for Perinatology and Human Development (CPHD, PAHO / WHO) with the goal of monitoring maternal, perinatal, and

[4] The orthogonality conditions in our GMM model are: $E[X_{i2}\ (\varepsilon_{i2} - \varepsilon_{i1})]=0$ for mothers with two deliveries in the period, $E[X_{i2}\ (\varepsilon_{i2}-\varepsilon_{i1})]=E[X_{i3}\ (\varepsilon_{i3} - \varepsilon_{i2})]=E[X_{i3}\ (\varepsilon_{i2}-\varepsilon_{i1})]=0$ for mothers with three deliveries, and $E[X_{i2}\ (\varepsilon_{i2}-\varepsilon_{i1})]=E[X_{i3}\ (\varepsilon_{i2}-\varepsilon_{i1})]=\ldots=E[X_{iT}\ (\varepsilon_{i2}-\varepsilon_{i1})]=0$, $E[X_{i3}\ (\varepsilon_{i3}-\varepsilon_{i2})]=E[X_{i4}\ (\varepsilon_{i3}-\varepsilon_{i2})]= \ldots E[X_{iT}\ (\varepsilon_{i3}-\varepsilon_{i2})]=0,\ldots,$ $E[X_{iT}\ (\varepsilon_{iT}-\varepsilon_{iT-1})]=0$, for mothers with T>3 deliveries.

infant health in Latin America and the Caribbean, and facilitating the use of information via standardized software. The PIS combines the different forms used to register pregnancy, birth outcomes, and neonatal care in the hospital (pre-natal clinical history, birth record, neonatal hospitalization form). The information is completed by a health professional and then entered into the system by the administrative staff. Uruguay joined the PIS in 1990, pursuing full coverage of obstetric episodes, complete filing of medical records, and internal consistency of the clinical history (CPHD, PAHO/ WHO, 1999). The extent of coverage of PIS at the Pereira Rossell Hospital is approximately 98.5% of all the births.

Because of the differencing methodology used in this paper, we worked with a sample of low SES Uruguayan women who gave birth to at least two children between 1995 and 2008. In Uruguay, low SES women have free access to prenatal and obstetric care. The data included information about the mother, the pregnancy, and the newborn's health. Of the 111,224 total births registered in the hospital in the period (about 8,000 births a year), 777 were discarded because of unviable pregnancies (less than 25 weeks of gestation or birth weights below 500 grams); 2,628 were not considered because of multiple pregnancies; and 6,150 were ignored because they lacked proper identification of the mother. Of the remaining observations (101,669), we discarded those with inconsistent information or missing values on relevant variables (5366 deliveries dropped) and considered only births to mothers who delivered at least twice during the period (32% of births). The final sample comprised 31,569 births (28% of all births in the hospital in the 1995-2008 period). Altogether, there were 13,758 mothers in the sample, of which 10,588 had 2 births, 2,435 had three, 601 had four, 122 had five, and 12 had six or more.

In Appendix Table A1, we compare women who had only one child in the analyzed period with those having more than one child. The table shows a regression of the different characteristics of women, pregnancy and childbirth on an indicator that takes the value of 1 if the woman gave birth only once. The regression compares characteristics of only the first pregnancy of women in each group, and adjusts for age and birth year at the time of delivery. There are no differences between the two groups in neonatal health outcomes caused by birth weight, low birth weight or gestational age at delivery. Nor are there differences in pregnancy risk factors such as hypertension, preeclampsia, and eclampsia. However, women with just one delivery show better use of prenatal care. These women are also more likely to be single or married than cohabiting. Those with a single delivery are more educated (more likely to have finished middle and high school), less likely to evidence risky habits (smoke less), less likely to have had a previous abortion and more likely to report pre-pregnancy weight. This preliminary comparison suggests some caution when extrapolating the results of the fixed effects analysis to women with one child.

The PIS data for Uruguay is quite unique in its ability to identify mothers across a period of 14 years. It is larger than similar data used in other medical and epidemiological studies, and provides information on a population of women who have not been studied intensively, with SES, cultural, and geographic differences relative to women in developed countries.

Birth weight is defined as a continuous variable capturing the newborn's weight in grams, and LBW is a binary variable that takes the value of 1 if the birth weight is 2500 grams or less, and 0 otherwise. The most immediate risk associated with low birth weight gestation is preterm delivery, which results in lower weight children. In this study, we consider that a delivery is pre-term if it occurs before the 37^{th} week of gestation.

We consider the following inputs in the production of child health: prenatal care, mother's age, use of tobacco during pregnancy, marital status, body mass index (BMI) prior to pregnancy, quarter of the delivery, and previous pregnancy history (number of abortions, total number of births, and total number of live births). We also consider measures of gestational maternal health, including hypertension, pre-eclampsia, and eclampsia. We conduct sensitivity analyses before and after adjusting for these conditions because these conditions may mediate the relationship between prenatal care and newborn's health.

Our analysis specifies three measures of prenatal care. The core measure is based on the Kessner Index, a widely used indicator that defines adequacy of care by its prompt initiation and a minimum number of visits, and adjusts these requirements for gestational age (Kotelchuck, 1994). According to Kessner's criteria, a woman has adequate prenatal care if she has her first visit during the first trimester (week 13 or earlier) and has at least nine visits at term, or between 4 and 8 visits in the case of a pre-term birth. Prenatal care is inadequate if she initiated the controls in the third quarter, or if care is initiated before, but she has less than 4 controls by the time of delivery, or between 1 and 3 visits when the birth is premature. All other combinations of initiation and visits belong to an intermediate category. The second categorization for prenatal care is based on the guidelines set by the MPH in Uruguay in 2010, which are the reference for the incentive payments received by providers. The variable takes the value of 1 if the woman initiated prenatal care in the first quarter of the pregnancy and had at least 6 control visits by the time of delivery. Finally, a third category focuses only on the timing of initiation of prenatal care, another variable widely used in the literature that takes the value of 1 if visits were initiated in the first trimester, and 0 otherwise. The inclusion of this variable seeks to make results comparable with those in some prior literature.

Tobacco use by the mother during pregnancy has been associated with lower birth weight (Permutt and Hebel, 1989; Veloso da Veiga and Wilder, 2008; Reichman et al., 2009). In our analysis, we specify a binary variable that takes the value of 1 if the woman reported smoking during pregnancy and 0 otherwise, and a continuous variable that specifies the average number of cigarettes smoked per day.

Previous research has also shown a clear relationship between maternal age and birth weight. Women who are either too young or are above the optimal age to conceive have the highest rates of low birth weight children compared with other child bearing women (Abel et al., 2002). In order to capture this association, we include five categories of maternal age: less than 16 years, between 17 and 19, between 20 and 34 (optimal age), between 35 and 39, and over 40.

We consider the mother's marital status and education as proxies for her socio-demographic status. A mother in a non-stable relationship is less likely to want the pregnancy. A negative attitude towards the baby can decrease the investment in care and health-related behaviors, and result in a lower birth weight (Joyce and Grossman, 1990; Reichman et al., 2009). Moreover, married women are more likely to have access to financial resources than single women. Reichman et al. (2009) conclude that women who are not married at the time of birth, smoke more cigarettes, consume more illicit drugs during pregnancy, and are less likely to receive prenatal care in the first trimester of pregnancy, all of which are associated with LBW. Regarding education, this variable predicts the purchasing power of the mother and the mother's efficiency in the production of health (Grossman, 1972; Grossman, 2000). A better-educated mother has the ability to produce children's health more effectively, probably because she understands the relationships between health inputs and outputs better. We expect better-educated mothers to be less likely to have children with low birth weights. To capture the effects of education on neonatal health, we specify binary variables indicating whether the mother completed primary education, middle school, or high school. There are almost no women in the sample that have completed tertiary education.

Among the mother's epidemiologic risk factors, we consider the body mass index (BMI) prior to pregnancy (self-reported) and the presence of following conditions during pregnancy: hypertension, pre-eclampsia, and eclampsia. The BMI is an indirect indicator of the mother's health, which has previously been associated with birth weight (Ehrenberg et al., 2003). Our analysis includes binary variables indicating four categories of maternal BMI before pregnancy: underweight (BMI <18.5), overweight ($25 \leq$ BMI <30), and obese (BMI ≥ 30). The normal BMI category ($18.5 \leq$ BMI <25) is the comparison group. Regarding other measures of the mother's health, chronic hypertension prior to pregnancy has been associated with lower birth weights (Haelterman et al., 1997).

Finally, the epidemiology literature shows that the experience of previous births is associated with anatomical changes that may impact the health of the newborn (Khong et al., 2003). Among these variables, we consider the number of prior births, episodes of mortality in prior deliveries, and prior abortions. For biological reasons, girls generally weigh less than boys, so we include a dummy variable that equals one if the newborn is a boy (Thomas et al., 2000).

Descriptive statistics are presented in Table 1. Within our sample, 10% of births are low weight (below 2500 grams), with the average birth weight being 3,150 grams. 14% are premature births (less than 37 weeks). Only 11% of pregnancies have a proper follow-up according to the Kessner criterion, 46% are inadequately followed-up, and the rest are in between. And only 17% of pregnancies meet the prenatal care goals set by the Uruguayan Ministry of Public Health, i.e., nearly half the women have 6 or more controls by the time of delivery, but only 21% of controls start in the first quarter.[5] These figures are quite surprising when considering that pregnancy care is free in Uruguay and that there are few geographic barriers to obstetric care facilities. Similar behavior, however, has been found among candidates for public assistance programs in the United States (Currie and Grogger, 2002; Kaestner and Lee, 2003).

Seventy percent of births are from mothers who are between 20 and 34 years old, almost 22% are from teenage mothers, and 8% are from women aged 35 or more. Only 20% of births occur within marriage, 59% of all births are to mothers living in common law with their partners, and the remaining 22% belong to single mothers or women with other marital status. The average education in the sample is low, as expected, considering that the hospital serves the population with the lowest income in Montevideo. Sixteen percent of all births are to women who did not complete primary education. The majority (62%) completed only primary school; 19% completed middle school, and only 3% completed high school. Two out of five women reported smoking during pregnancy and the average number of cigarettes per day is 3.7. Half of the observations are missing information on the mother's weight and height. Among those with information, 6% of new mothers showed low pre-pregnancy weight and 11% were overweight or obese. The number of previous births is 2.2; 3% report a prior death of a newborn within the first week of life, and 17% report having had an abortion. As for the conditions that can cause complications during pregnancy, 2.2% of the sample has hypertension and 2% has pre-eclampsia. Births are distributed almost equally across the different quarters of the year.

5. Results

Estimation Assuming No Feedback Effects

[5] The fraction of women with adequate prenatal care increases from 12% to 20% between 1995 and 2006, but suffers a drop of 5 percentage points in 2007 and 2008.

Table 3 shows the results of the estimation when the adequacy of prenatal care is defined in terms of the Kessner index and there is no correction for feedback effects. Each column in Table 2 depicts the estimates of a linear regression model on a panel of observations that have been transformed to within-mother first differences. Results show large effects of prenatal care on the likelihood of preterm birth (column 1) and low birth weight (columns 2 and 3). An adequate use of prenatal care decreases the likelihood of preterm birth by 10 percentage points, a decrease of 69% relative to the mean, and the likelihood of LBW by more than half, specifically by 5.5 percentage points. Even if prenatal care is not fully adequate in the sense of Kessner, women initiating care before the third trimester and showing at least four prenatal visits by the end of the pregnancy (intermediate prenatal care) are 7.0 percentage points less likely to experience a preterm birth and 3.4 percentage points less likely to deliver a baby below 2500 grams than women with inadequate use. Once we adjust for gestational age (Column 3), the estimated impact of adequate and intermediate care on LBW decreases by more than half, suggesting that preterm care improves birth weight both through a reduction in the likelihood of a preterm birth and by increasing the weight at each gestational age.

Both the probability of LBW and the likelihood of preterm birth are higher for teenage mothers (19 years or less) and for mothers with prior obesity or preeclampsia; they are lower for mothers who suffered from a still birth in a prior pregnancy. LBW is also positively associated with being a smoker, with a first pregnancy, and with a female baby.

Estimation Under Feedback Effects

We next relax the assumption of independence between the demand for prenatal care and prior shocks to the prenatal health production function. We address feedback effects by running a difference GMM model that uses levels of one-or more- period lagged variables as instruments for the deviations in contemporary variables. In addition to instrumenting prenatal care, we instrument the following other characteristics, which are also likely to be predetermined by past shocks: maternal use of tobacco, mother's body mass index, and fertility history (prior number of births, stillbirths, and abortions). All other controls are assumed exogenous, except for gestational age, which is treated as endogenous, and is instrumented with an additional lag. Because this instrument is more imprecise, the results that adjust for gestational age are more likely to be subject to weak instrument problems. Using the Hansen J statistic, we cannot reject the hypothesis that the instruments are orthogonal to the error term.

Results are presented in Table 3. Once we take feedback effects into consideration, the estimates of interest are still significant, large, and with the right sign. Adequate care in the Kessner sense continues reducing the likelihood of preterm birth by 70% and the likelihood of LBW by 50%. There is a slight decrease in the coefficients on the Kessner measure of intermediate care: the effect on preterm birth is now -0.058 (relative to -0.07 in Table 2) and the effect on LBW is -0.025 (compared to a previous estimate of -0.034). Unlike the prior estimates, the effect on LBW disappears after controlling for gestational age. We are less comfortable with the results in this column because it requires instrumenting the differences in gestational age with a two period lag; the estimates are only valid for mothers with at least three deliveries and the instrument is imprecise.

Table 4 compares the results of the model with feedback effects (Table 3) and that in first differences displayed in Table 2, with OLS estimates. The effect of adequate prenatal care on prematurity and LBW is very similar across the three different methods. However, there are some differences in the coefficients on intermediate prenatal care. Intermediate use of prenatal care shows the largest effects on prematurity and LBW when the model is estimated using OLS (the coefficients are -0.088 and -0.046 respectively). The coefficients decrease to -0.070 and -0.034 in the first difference model, and to -0.058 and -0.025 in the difference-GMM feedback effects model. This comparison suggests that the failure to consider time invariant unobserved heterogeneity and feedback effects inflates the estimates by 33% in the case of preterm birth and by 46% when analyzing LBW.

To assess the robustness of the difference-GMM estimates, we rerun the model under different assumptions about the predetermined nature of other controls (all robustness results are available upon request). We consider only instrumenting for prenatal care, or instrumenting for subsamples of the predetermined variables in the core model. There is little variation in the coefficients of adequate and intermediate prenatal care under these alternative estimations.

We also test for sensitivity by rerunning the above specification under different sets of control variables. We find no differences between the core estimates and estimates that do not adjust for maternal morbidity conditions (hypertension, pre-eclampsia and eclampsia), for mother's body mass index, tobacco use, or for prior history of stillbirths, parity, or abortions. On the other hand, the coefficients on prenatal care decrease when we do not adjust for the indicator of first birth.[6]

Finally, we run a model only on the sample of women who had their first and second deliveries in the period under analysis. The idea of this exercise is to assess the heterogeneity of results in different subpopulations, i.e., in those women with just two births versus those with more than two births. Results suggest that prenatal care is less effective in avoiding LBW, prematurity, or LBW conditional on gestational age for women with fewer prior births.[7]

Other measures of adequacy of prenatal care: Early Initiation and Guidelines of the Uruguayan Ministry of Public Health

Tables 5 and 6 present the findings for alternative measures of adequate prenatal care. All estimates are derived from difference-GMM models that use one-period lagged levels of prenatal care, smoking, body mass index, and fertility history as instruments for current deviations in these variables.

Table 5 shows the effects of initiation of care during the first trimester on the likelihood of pre-term delivery and LBW. When compared to results in Table 3, these estimates give a sense of the relative importance of early initiation versus number of controls in the overall effect of adequacy of care. Early initiation has some impact on the likelihood that the pregnancy reaches full- term, but much smaller than the aggregate effect of early initiation plus an adequate number of controls: initiation during the 1st trimester decreases a preterm birth by 2.6 percentage points. It has no impact, on the other hand, on the likelihood of low birth weight in the specification that does not adjust for gestational age. This finding suggests that the positive

[6] There are also few differences between our core estimates and those resulting from the within estimator or the forward orthogonal deviations estimator.
[7] While the effect of prenatal care on birth weight initially appears higher than that for the full sample, it becomes smaller than the full sample estimates once gestational age is accounted for.

effect of prenatal care on birth weight would be playing mostly through an adequate number of controls. It also highlights the importance of quantifying the number of controls in addition to the time of initiation in studies analyzing the effectiveness of prenatal care.

Table 6 shows the effects of compliance with the standards of prenatal care set by the Uruguayan Ministry of Public Health. Complying with the MPH standards decreases the likelihood of prematurity by 4.3 percentage points, a reduction from 14 to 9.7 percentage points. The effects on LBW are also statistically significant and large: initiating care during the first trimester and having at least six visits by the term of the pregnancy reduces the likelihood of LBW by 3.1 percentage points (a 30% decrease).

The comparison between the Kessner effects and those estimated with the guidelines of the MPH suggests that increasing the target number of controls beyond those required by the MPH may lead to more pronounced falls in the probability of LBW. Note that there is less than half a percentage point difference between the impact of the Uruguayan MPH guidelines on LBW (-0.031) and the coefficient on the Kessner measure of intermediate care (-0.025). However, there is a bigger difference (of almost two percentage points) between the Uruguayan guidelines and the Kessner measure of adequacy of care. These additional three controls required in the Kessner measure of adequacy appear to have a large impact on birth outcomes. Moreover, much of the beneficial impact of this increased number of controls seems to operate through a smaller probability of pre-term birth. Proper use of prenatal care according to the Kessner criterion reduces the likelihood of prematurity by 11 percentage points, a 79% decrease when compared to the average rate of prematurity in the sample.

The measure of adequacy of prenatal care as defined by the MPH does not adjust for gestational age, imposing more stringent standards on riskier pregnancies. A mother delivering before the 30th week is unlikely to satisfy the minimum of 6 controls, even if she has been complying with the expected standard of care. While this is a limitation of the goal set by MPH, we rerun the core model using a gestational-age adjusted measure of adequacy of care.[8] Twenty-nine women that were previously categorized as having inadequate care are now classified into the adequate category. As expected, the impact of prenatal care is lower, but still considerable in magnitude and statistically significant. The coefficient on the adjusted measure of prenatal care equals -0.023 when explaining low birth weight and -0.047 when explaining preterm birth.

Limitations

Our findings rely on the assumption that unobserved heterogeneity across mothers is time-invariant. Results are not necessarily robust to specifications considering time variant shocks associated both with the demand for prenatal care and the outcomes of the pregnancy (i.e., a new health condition, improved information or changes in preferences). Unfortunately, we did not have precise instruments to treat prenatal care as a contemporary endogenous (rather than predetermined) variable. Still, there are some reasons to believe that any effects of time variant heterogeneity would not have had a large impact on the estimated coefficients. First, our models already address time variant heterogeneity stemming from aggregate shocks and from mother's health endowments. Time variant aggregate shocks such as information campaigns, increase in the quality of prenatal care, or a better economy are contemplated in the year fixed effects. At the individual level, we are contemplating changes in the mother's health endowment by the inclusion of controls for preeclampsia, eclampsia, and hypertension that are pregnancy specific. Moreover, the estimates are not too sensitive to the exclusion of these co-morbid conditions from the regression. We recognize that our model fails to account for negative shocks to the fetus' health endowment, which are likely to affect both birth outcomes and the decisions regarding prenatal care. But if such an effect were important, it would operate by biasing the estimates towards zero. In such case, our estimates would be conservative.

6. Conclusions

[8] The new measure accepts 4 controls (plus early initiation) as an adequate standard of care in the case of women delivering between the 22nd and the 25th week, and 5 controls (plus early initiation) in the case of women delivering between the 26th and 29th week.

This paper estimates the effect of prenatal care on infant health by exploiting intra-mother variations in inputs and outcomes of pregnancies. We analyze a longitudinal panel of births that took place between 1995 and 2008 in the biggest public maternity ward in Uruguay. The data set is quite unique in its ability to identify mothers throughout the period, its large size, its reliance on clinical history (rather than self-reports), and its focus on low SES women in a less developed country. The use of difference GMM estimation addresses potential biases due to unobserved heterogeneity and feedback effects from prior births.

Our findings show that adequate use of prenatal care, as defined by early initiation and a minimum number of visits throughout the pregnancy, has a significant positive impact on neonatal outcomes. The probability of low birth weight falls by between 30% and 50% depending on the minimum number of controls that are considered "adequate" (six or nine respectively), and the reduction in the likelihood of pre-term birth ranges respectively from 34% to 70%.

We find that unobserved heterogeneity and feedback effects are likely to inflate the estimates of prenatal care on birth outcomes. Still, even after taking these effects into account, our estimates are larger than those obtained in other international investigations using two stages least squares (2SLS) and exploiting health policy changes as instruments. While the population we analyze is likely to have more space for improvement, our results are also compatible with the critique that local average treatment effects, identified by 2SLS, underestimate the full effectiveness of prenatal care. This is because they do not consider the full distribution of pregnancies, and also fail to account for the bimodal nature of error terms in the pregnancy distribution.

Several factors mediate the effectiveness of prenatal care on neonatal outcomes: the physician’s influence on the woman’s behavior during pregnancy (protein supplementation, abstinence from alcohol, tobacco, and other drugs, among other behaviors), the detection and treatment of conditions associated with low birth weight (syphilis, anemia, hypertension, urinary infections), and the preparation for delivery. Future research should explore these mechanisms.

Policy-wise, our findings have direct implications for developing countries, and particularly, for the Uruguayan population. If the low-income population in Uruguay achieved the prenatal care goals set by the MPH, the impact on neonatal health would be strong. However, only 17% of the population in our sample complies with the standards suggested by the MPH, and only 11% shows adequate use of prenatal care as defined by the Kessner criterion. These low figures, together with the potential effects encountered, present a strong case for the design of policies aimed at encouraging the use of prenatal care in low SES populations. The financial incentives being offered by the Ministry of Health to health care providers for achieving a set of prenatal care goals may not be sufficient to promote significant changes among the lower-income populations. Any policy aimed at improving prenatal care among low SES women, either through incentives to the providers or directly through conditional cash transfers or other demand-centered initiatives, must focus differentially on the segments of the population less likely to use prenatal care adequately, i.e. teenagers or women above 35, women that are single, uneducated, or that have many children. Conditional cash transfer programs, which provide financial aid to low income individuals upon compliance with health and education goals, should also align their incentives to elicit better compliance with prenatal care optimal standards.[9]

[9] There is some evidence in Uruguay that the PANES, an emergency financial aid plan that took place after the 2002 crisis had some positive impact on infant's birth weight (Manacorda, Amarante, Vigorito 2011). However, the effects did not seem to work through improved prenatal care.

References

Abel E.L., Kruger M., Burd L. 2002.Effects of Maternal and Paternal Age on Caucasian and Native American Preterm Births and Birth weights. *American Journal of Perinatology* 19:49-54.

Abrevaya, J. 2006. Estimating the effect of Smoking on Birth Outcomes Using a Matched Panel Data Approach. *Journal of Applied Econometrics* 21: 489-519.

Alexander G.R., Korenbrot C.C. 1995. The role of prenatal care in preventing low birth weight. *Future Child* 5(1):103-20.

Barros F.C., Bhutta Z.A., Batra M., Hansen T.N., Victora C.G., Rubens C.E.2010. Global report on preterm birth and stillbirth (3 of 7): evidence for effectiveness of interventions. *BMC Pregnancy Childbirth* 10 Suppl 1:S3.

Behrman J.R., Rosenzweig M.R. 2005. Returns to Birth weight. *Review of Economic and Statistics* 86 (2): 586-601.

Black S., Devereux P., Salvanes K. 2007. From the Cradle to the Labor Market? The Effect of Birth weight on Adult Outcomes. *Quarterly Journal of Economics*122 (1): 409-439.

Boardman J.D., Powers D.A., Padilla Y.C., Hummer R.A. 2002. Low birth weight, social factors, and developmental outcomes among children in the United States. *Demography* 39 (2): 353–363.

Bortman M. 1998. Factores de Riesgo de Bajo Peso al Nacer (RiskFactorsforLowBirthweight). *Revista Panamericana de Salud Publica* 3:314-321.

Brien M.J., Swann C.A. 2001. Prenatal WIC Participation and Infant Health: Selection and Maternal Fixed Effects. Manuscript, SUNY-Stony Brook Department of Economics.

Briozzo L. 2003. Aborto provocado: un problema humano. Perspectivas para su análisis-estrategias para su reducción. *Revista Médica del Uruguay* 19(3): 188-200.

Capurro A., Recchi V. 1994. Bajo peso al nacer. Factores determinantes. *Archivos de Ginecología y Obstetricia* 33(1):35-42.

Case A., Fertig A., Paxson C. 2004. The Lasting Impact of Childhood Health and Circumstance. Center for Health and Well Being, Woodrow Wilson School, Princeton University.

Centro Latinoamericano de Perinatología y Desarrollo Humano (CLAP-OPS/OMS).http://www.clap.hc.edu.uy.

Conde-Agudelo A., Belizán J.M. 2000. Maternal Morbidity and Mortality Associated with Interpregnancy Interval: A Cross Sectional Study. *British Medical Journal* 321:1255-1259.

Cramer J.C. 1995. Racial Differences in Birth weight: The Role of Income and Financial Assistance. *Demography* 32:231-247.

Clement, S., et al., 1999. Does reducing the frequency of routine antenatal visits have long term effects? Follow up of participants in a randomized controlled trial. *British Journal of Obstetrics and Gynecology* 106 (4), 367–370.

Conway K.S., Deb P. 2005. Is prenatal care really ineffective? Or, is the 'devil' in the distribution? *Journal of Health Economics* 24 (3): 489-513.

Currie J., Madrian B. 1999. Health, Health Insurance, and the Labor Market. In Orley Ashenfelter and David Card (eds.) *Handbook of Labor Economics*, v3, 3309-3415.

Currie J., Moretti E. 2005. Biology as destiny? Short and long-run determinants of intergenerational transmission of birth weight. *NBER WP* 11567.

Currie J., Grogger J. 2002. Medicaid Expansions and Welfare Contractions: Offsetting Effects on Prenatal Care and Infant Health? *Journal of Health Economics* 21:313-336.

Díaz A. G, Schwarcz R., Fescina R., DíazRossello J. L. 1985. El bajo peso al nacer en América Latina. *Clin.Ginecol. Obstet. Perinat* 2(1):3-9.

Ehrenberg H.M., Dierker L., Milluzzi C., Mercer B.M. 2003. Low Maternal Weight, failure to Thrive in Pregnancy, and Adverse Pregnancy Outcomes. *American Journal of Obstetrics and Gynecology* 189:1726-1730.

Frisbie W.P., Forbes D., Pullum S.G. 1996. Compromised Birth Outcomes, and Infant Mortality Among Racial and Ethnic Groups. *Demography* 33:469-481.

Grossman M. The Human Capital Model. 2000. In The Handbook of Health Economics, Anthony Culyer and Joseph P. Newhouse (eds.).

Grossman M. 1972. On the Concept of Health Capital and the Demand for Health. *Journal of Political Economy* 80:223-255.

Grossman M., Joyce T.J. 1990. Unobservables, Pregnancy Resolutions, and Birth weight Production Functions in New York City. *Journal of Political Economy* 98: 983-1007.

Grossman, M. 2000. "The Human Capital Model."In *Handbook of Health Economics* Vol. 1A, edited by A. J. Culyer and J. P. Newhouse. Amsterdam: North-Holland, Elsevier Science, 347-408.

Guilkey D.K., Popkin B.M., Akin J.S., Wong E.L. 1989. Prenatal Care and Pregnancy Outcome in Cebu, Philippines. *Journal of Development Economics* 30:241-272.

Haelterman E., Breart G., Paris-Llado J., Dramaix M., Tchobroutsky C. 1997.Effect of Uncomplicated Hypertension on the Risk of Small-for-Gestational Age Birth. *American Journal of Epidemiology* 145: 689-695.

Hobel C.J., Ross M.G., Bemis R.L., Bragonier J.R., Nessim S., Sandhu M., Bear M.B., Mori B. 1994. The West Los Angeles Preterm Birth Prevention Project. I. Program impact on high-risk women. *Am J Obstet Gynecol* 170(1 Pt 1): 54-62.

Holtz-Eakin, D., W. Newey, and H.S. Rosen. 1998. Estimating vector autoregressions with panel data. *Econometrica* 56: 1371-95.

Institute of Medicine. 1985. *Preventing Low Birth weight*. Washington, DC: National Academy.

Jewell R.T., Triunfo P. 2006. The Impact of Zero-Cost Prenatal Care on Birth weight: The Case of the Urban Poor in Uruguay. *Health Economics* 15: 1245-1250.

Jewell R.T., Triunfo P., Aguirre R. 2007. El peso al nacer de los niños en la principal maternidad del Uruguay: 1995 a 2004. *Revista Desarrollo y Sociedad* 59:1-20, Universidad de los Andes, Colombia.

Joyce T.J., Grossman M. 1990. Pregnancy Wantedness and the Early Initiation of Prenatal Care. *Demography* 27:1-17.

Kaestner R., Lee W.C. 2003. The Effect of Welfare Reform on Prenatal Care and Birth weight. *NBER WP* 9769.

Kaestner R. 1999. Health insurance, the quantity and quality of prenatal care, and infant health. *Inquiry* 36(2):162-75.

Khong T.Y., Adema E.D., ErwichJ.J.H.M.. 2003. On an Anatomical Basis for the Increase in Birth weight in Second and Subsequent Born Children. *Placenta* 24:348-353.

Kleinman J.C., Kessel S.S. 1987. Racial Differences in Low Birth weight: Trends and Risk Factors. *New England Journal of Medicine* 317:749-753.

Kotelchuck M. 1994. An Evaluation of the Kessner Adequacy of Prenatal Care Index and a Proposed Adequacy of Prenatal Care Utilization Index. *American Journal of Public Health* 84:1414-1420.

Li K., Poirier D.J. 2003a. An Econometric Model of Birth Inputs and Outputs for Native Americans. *Journal of Econometrics* 113: 337-361.

Li K., Poirier D.J. 2003b. Bayesian Analysis of an Econometric Model of Birth Inputs and Outputs. *Journal of Population Economics* 16:597-625.

Liu G.G. 1998. Birth Outcomes and the Effectiveness of Prenatal Care. *Health Services Research* 32:805-823.

Lu M.C., Tache V., Alexander G.R., Kotelchuck M., Halfon N. 2003. Preventing low birth weight: is prenatal care the answer? *J Matern Fetal Neonatal Med* 13(6): 362-80.

Matijasevich A, Barros F, Díaz Rossello JL, Forteza C, Bergel E. 2002. Maternal risk factors associated with very low birth weight (<1500 g. VLBW) and birth weight between 1500 - 2499g. *Pediatric Research* 52(9): 466.

McCormick M.C. 1985. The Contribution of Low Birth weights to Infant Mortality and Childhood Morbidity. *New England Journal of Medicine* 312: 82-90.

McDuffie, R., et al., 1996.Effect of frequency of prenatal care visits on perinatal outcome among low-risk women. *The Journal of the American Medical Association* 275: 847–851.

Ministerio de Salud Pública (MSP). 2010. Ver Instructivo de metas asistenciales JUNASA_MSP, en *www.msp.gub.uy*.

Misra, D., Guyer, B., 1998. Benefits and limitations of prenatal care: from counting visits to measuring content. *The Journal of the American Medical Association* 279: 1661–1662.

Murray J., Bernfield M. 1988.The Differential Effect of Prenatal Care on the Incidence of Low Birth weight among Blacks and Whites in a Prepaid Health Care Plan. *N Engl J Med* 319:1385-1391.

Permutt T., Hebel J.R. 1989. Simultaneous-Equation Estimation in a Clinical Trial of the Effect of Smoking on Birth weight. *Biometrics* 45:619-622.

Petrou, S., Sach, T. and Davidson, L. 2001. The long-term costs of preterm birth and low birth weight: results of a systematic review. *Child: Care, Health and Development*, 27:97-115.

Poirier D.J. 1998. Modeling Birth weight: US Stylized Facts and a Window for Viewing Them. Unpublished manuscript, University of Toronto.

Reichman N.E., Corman H., Noonan K., Dave D. 2009. Infant health production functions: What a difference the data make? *Health Economics* 18(7): 761-782.

Roodman, D. 2006. How to Do xtabond2: An Introduction to Difference and System GMM in Stata. *Center for Global Development* ,WP 103.

Rosenzweig M.R., Schultz T.P. 1982. The Behavior of Mothers as Inputs to Child Health: The Determinants of Birth weight, Gestation, and Rate of Fetal Growth. In *Economic Aspects of Health*, edited by V.R. Fuchs. Chicago, Illinois: University of Chicago Press.

Rosenzweig M.R., Schultz T.P. 1983. Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and Their Effects on Birth weight. *Journal of Political Economy* 91:723-746.

Rosenzweig M.R., Schultz T.P. 1988. The Stability of Household Production Technology: A Replication. *Journal of Human Resources* 23:535-549.

Rous J.J., Jewell R.T, Brown R.W. 2003. The Effect of Prenatal Care on Birth weight: A Full-Information Maximum Likelihood Approach. *Health Economics* 13:251-264.

Sosa C G, Sotero, GA, Domínguez A, Cuadro C, Martínez J. 2001. Perinatal outcomes in the largest maternity of Uruguay. *Journal of Perinatal Medicine* 29 (suppl.1): p. 29.

Thomas P., Peabody J., Turnier V., Clark R.H. 2000. A New Look at Intrauterine Growth and the Impact of Race, Altitude, and Gender. *Pediatrics* 106:E21.

Veloso da Veiga P., Wilder R. 2008. Maternal Smoking During Pregnancy and Birth weight: A Propensity Score Matching Approach. *Matern Child Health Journal* 12: 194–203.

Villar, J., et al., 2001. Who antenatal care randomized trial for the evaluation of a new model of routine antenatal care. *Lancet* 357 (9268), 1551–1564.

Warner G. 1998. Birth weight Productivity of Prenatal Care. *Southern Economic Journal* 65(1): 42-63, July.

Wehby G. L., Murray, J.C., Castilla, E.E., Lopez-Camelo, J.S.,Ohsfeldt, R.L. 2009. Quantile effects of prenatal care utilization on birth weight in Argentina. *Health Economics* 18 (11): 1307-1321.

Table 1. Summary Statistics

Variable	Mean (1)	Standard Deviation (2)
Low Birth weight< 2500 grams	0.099	0.299
Birth weight in grams (min=0.6, max=6.3)	3148.7	566.2
Pre-termbirth	0.144	0.351
Mother had Adequate Prenatal Care (MPH)	0.173	0.378
Initiated prenatal care in the first trimester	0.206	0.405
At least six prenatal care visits	0.486	0.500
Inadequate Prenatal Care Kessner	0.459	0.498
Intermediate Prenatal Care Kessner	0.434	0.496
Adequate Prenatal Care Kessner	0.107	0.309
Age<16	0.048	0.214
Age 20-34	0.699	0.459
Age 35-39	0.066	0.248
Age>39	0.017	0.130
Marital Status: Cohabitation	0.588	0.492
Marital Status: Single	0.197	0.398
Marital Status: Other	0.019	0.137
Marital Status: Married	0.196	0.397
Education: did not finish primary school	0.158	0.364
Education: completedprimaryschool	0.622	0.485
Education: completedmiddleschool	0.191	0.393
Education: completedhighschool	0.029	0.169
Smoker	0.392	0.488
Number of Cigarettes per day (max=85)	3.677	6.547
Mother is Underweight(BMI<18.5)	0.056	0.230
Mother is Overweight ($25 \leq$ BMI < 30)	0.075	0.263
Mother is Obese (BMI $\geq$ 30)	0.032	0.177
Missing BMI	0.508	0.500
Parity (max=16)	2.192	2.143
Previous still birth	0.031	0.172
Previous abortions	0.174	0.379
Hypertension	0.022	0.138
Missing Hypertension	0.083	0.276
Pre-eclampsia	0.020	0.133
Missing Pre-eclampsia	0.083	0.276
Eclampsia	0.001	0.030
Missing Eclampsia	0.084	0.277
Child'sgender: Male	0.514	0.500
Trimester of birth: 1	0.241	0.428
Trimester of birth: 2	0.252	0.434
Trimester of birth: 3	0.263	0.440
N	31569	

Table 2. Effects of Adequate Prenatal Care (Kessner Index) on Birth Outcomes

Regression with Mother-Specific First Differences

Mothers with at least two deliveries between 1995 and 2008

Outcome	Pre-term Birth	Low Birthweight No control for gestational age	LowBirth weight Adjustingforgestationalage
	(1)	(2)	(3)
Intermediate Prenatal Care (Kessner)	-0.070***	-0.034***	-0.014***
	(0.006)	(0.005)	(0.005)
Adequate Prenatal Care (Kessner)	-0.099***	-0.055***	-0.025***
	(0.009)	(0.008)	(0.007)
Gestational age (weeks)			-0.052***
			(0.001)
Smoker	0.002	0.017**	0.013**
	(0.008)	(0.007)	(0.006)
Age<17	0.050***	0.033**	0.009
	(0.018)	(0.015)	(0.013)
Age 17-19	0.024**	0.021***	0.007
	(0.009)	(0.008)	(0.007)
Age 35-39	0.022	-0.003	-0.008
	(0.016)	(0.012)	(0.011)
Age>39	0.046	0.003	-0.017
	(0.029)	(0.023)	(0.021)
Cohabitation	0.005	0.003	0.002
	(0.011)	(0.009)	(0.008)
Single	0.010	-0.003	-0.002
	(0.012)	(0.010)	(0.009)
Other Marital Status	-0.003	0.017	0.026
	(0.022)	(0.018)	(0.016)
Finished Primary	0.011	-0.010	-0.016*
	(0.013)	(0.010)	(0.009)
Finished Middle School	-0.007	-0.023*	-0.021*
	(0.016)	(0.012)	(0.011)
Finished High School	-0.017	-0.004	-0.003
	(0.022)	(0.018)	(0.015)
Motheris Underweight	-0.007	-0.010	-0.007
	(0.014)	(0.012)	(0.011)
Motheris Overweight	0.017*	0.001	-0.004
	(0.010)	(0.008)	(0.007)
Motheris Obese	0.036**	0.029**	0.015
	(0.016)	(0.013)	(0.011)
Missing BMI	0.033***	0.021***	0.007
	(0.006)	(0.005)	(0.005)
Previous stillbirth	-0.086***	-0.085***	-0.043**
	(0.023)	(0.021)	(0.017)
N Previous abortions	-0.003	0.005	0.006
	(0.007)	(0.006)	(0.005)
Parity	0.009	-0.002	-0.007*
	(0.005)	(0.004)	(0.004)

First Pregnancy	0.006	0.035***	0.033***
	(0.008)	(0.007)	(0.006)
Hypertension	-0.006	0.012	0.013
	(0.021)	(0.018)	(0.017)
Missing Hypertension	-0.053	0.033	0.067
	(0.079)	(0.077)	(0.067)
Preeclampsia	0.142***	0.093***	0.045**
	(0.025)	(0.022)	(0.019)
Missing Preeclampsia	0.077	-0.064	-0.082
	(0.099)	(0.100)	(0.087)
Eclampsia	0.285***	0.146	0.031
	(0.094)	(0.109)	(0.092)
Missing Eclampsia	-0.060	0.026	0.019
	(0.103)	(0.116)	(0.097)
Male	0.009*	-0.012***	-0.013***
	(0.005)	(0.004)	(0.004)
Trimester of birth: 1	0.008	-0.013**	-0.017***
	(0.007)	(0.006)	(0.005)
Trimester of birth: 2	0.016**	-0.004	-0.012**
	(0.007)	(0.006)	(0.005)
Trimester of birth: 3	0.003	-0.008	-0.011**
	(0.007)	(0.006)	(0.005)
Year Fixed Effects	Yes	yes	yes
	17370	17370	17370

Robust standard errors in parentheses. * p<0.1, ** p<.05, *** p<.01

Table 3. Effects of Adequate Prenatal Care (Kessner index) on Birth Outcomes
Difference-GMM using levels of past prenatal care as instruments for contemporary deviations
Mothers with at least two deliveries between 1995 and 2008. Robust standard errors in parentheses.

Outcome:	Pre-term birth (1)	LBW No control for gestational age (2)	LBW Adjusting for gestational age (3)
Intermediate Prenatal Care	-0.058***	-0.025***	-0.006
	(0.010)	(0.008)	(0.009)
Adequate prenatal care	-0.101***	-0.050***	-0.016
	(0.015)	(0.012)	(0.014)
Gestational age (weeks)			-0.047***
			(0.012)
Smoker	0.013	0.015	0.014
	(0.017)	(0.014)	(0.012)
Age<17	0.055***	0.034**	0.011
	(0.019)	(0.015)	(0.014)
Age 17-19	0.027***	0.022***	0.009
	(0.010)	(0.008)	(0.008)
Age 35-39	0.018	-0.004	-0.008
	(0.016)	(0.012)	(0.011)
Age>39	0.031	-0.003	-0.016
	(0.029)	(0.023)	(0.021)
Cohabitation	0.005	0.003	0.002
	(0.011)	(0.009)	(0.008)
Single	0.011	-0.003	-0.003
	(0.012)	(0.010)	(0.009)
Other Marital Status	-0.002	0.018	0.025
	(0.022)	(0.018)	(0.016)
Finished Primary	0.011	-0.010	-0.015*
	(0.013)	(0.010)	(0.009)
Finished Middle School	-0.007	-0.023*	-0.021*
	(0.016)	(0.012)	(0.011)
Finished High School	-0.015	-0.005	-0.004
	(0.022)	(0.018)	(0.016)
Motheris Underweight	0.007	-0.003	0.001
	(0.021)	(0.018)	(0.016)
Motheris Overweight	0.056***	0.020	0.010
	(0.017)	(0.013)	(0.012)
Motheris Obese	0.084***	0.051**	0.034
	(0.028)	(0.022)	(0.021)
Missing BMI	0.060***	0.031***	0.012
	(0.011)	(0.009)	(0.009)
Previous stillbirth	0.016	-0.012	-0.006
	(0.047)	(0.044)	(0.038)
N Previous abortions	-0.000	0.019	0.020
	(0.024)	(0.020)	(0.017)
Parity	0.026**	0.000	-0.008

	(0.012)	(0.009)	(0.008)
First Pregnancy	0.017*	0.039***	0.033***
	(0.009)	(0.008)	(0.007)
Hypertension	-0.009	0.010	0.011
	(0.021)	(0.018)	(0.017)
Missing Hypertension	-0.054	0.034	0.064
	(0.078)	(0.076)	(0.068)
Preeclampsia	0.144***	0.094***	0.050**
	(0.025)	(0.023)	(0.022)
Missing Preeclampsia	0.080	-0.066	-0.082
	(0.098)	(0.100)	(0.088)
Eclampsia	0.293***	0.153	0.048
	(0.094)	(0.108)	(0.097)
Missing Eclampsia	-0.061	0.026	0.023
	(0.101)	(0.115)	(0.098)
Male	0.009*	-0.012***	-0.013***
	(0.005)	(0.004)	(0.004)
Trimester of birth: 1	0.011	-0.012*	-0.016***
	(0.008)	(0.006)	(0.006)
Trimester of birth: 2	0.018**	-0.004	-0.011**
	(0.007)	(0.006)	(0.006)
Trimester of birth: 3	0.004	-0.007	-0.010**
	(0.007)	(0.006)	(0.005)
Year Fixed Effects	Yes	Yes	yes
	17370	17370	17370

Robust standard errors in parentheses. * p<0.1, ** p<.05, *** p<.01

Table 4. Effects of Adequacy of Prenatal Care, as defined by the Kessner Index, on Birth Outcomes

Comparison of OLS, first-differences, and difference-GMM estimation

Mothers with at least two deliveries between 1995 and 2008.

	Preterm Birth (1)	Low Birth weight No control for gestational age (2)	Low Birth weight Controlling for gestational age (3)
Ordinary Least Squares			
Intermediate Prenatal Care (Kessner)	-0.088***	-0.046***	-0.013*
	(0.004)	(0.004)	(0.007)
Adequate Prenatal Care (Kessner)	-0.104***	-0.054***	-0.007
Model in First Differences			
Intermediate Prenatal Care (Kessner)	-0.070***	-0.034***	-0.014***
	(0.006)	(0.005)	(0.005)
Adequate Prenatal Care (Kessner)	-0.099***	-0.055***	-0.025***
	(0.009)	(0.008)	(0.007)
Difference-GMM with feedback effects			
Intermediate Prenatal Care (Kessner)	-0.058***	-0.025***	-0.006
	(0.010)	(0.008)	(0.009)
Adequate prenatal care (Kessner)	-0.101***	-0.050***	-0.016
	(0.015)	(0.012)	(0.014)

All estimations include the full set of controls depicted in Table 2. Robust standard errors in parentheses. * p<0.1, ** p<.05, *** p<.01.

Table 5. Effects of Early Initiation of Prenatal Care on Birth Outcomes

Difference-GMM estimation

Mothers with at least two deliveries between 1995 and 2008.

	Preterm Birth (1)	Low Birth weight No control for gestational age (2)	Low Birth weight Controlling for gestational age (3)
Initiation during 1st trimester	-0.026***	-0.012	-0.015**
	(0.009)	(0.008)	(0.007)
Gestational age (weeks)			-0.044***
			(0.012)

All estimations include the full set of controls depicted in Table 2. Robust standard errors in parentheses. * p<0.1, ** p<.05, *** p<.01.

Table 6. Effects of Adequacy of Prenatal Care according to Uruguayan MPH Guidelines

Difference-GMM estimation

Mothers with at least two deliveries between 1995 and 2008

	Preterm Birth (1)	Low Birth weight No control for gestational age (2)	Low Birth weight Controlling for gestational age (3)
Adequate prenatal care (MPH)	-0.031***	-0.043***	-0.018**
	(0.008)	(0.010)	(0.008)
Gestational age (weeks)			-0.048***
			(0.012)

All estimations include the full set of controls depicted in Table 2. Robust standard errors in parentheses. * p<0.1, ** p<.05, *** p<.01.

Appendix Table A1: Comparison of first pregnancy characteristics between women that gave birth to one child and women that gave birth to more than one child between 1995 and 2008.

Dependent variables:	Explanatory variable: Gave birth to only one child between 1995-2008#
Low Birthweight	0.003
	(0.005)
Birthweight (grams)	11.028
	(8.468)
Premature	0.002
	(0.005)
Adequate Prenatal Care MSP	0.018***
	(0.007)
Intermediate Prenatal Care Kessner	0.014*
	(0.007)
Adequate Prenatal Care Kessner	0.020***
	(0.006)
Cohabitation	-0.058***
	(0.007)
Single	0.022***
	(0.007)
Other Marital Status	0.002**
	(0.001)
Without Primary	-0.038***
	(0.005)
Finished Primary	-0.062***
	(0.007)
Finished Middle School	0.084***
	(0.006)
Finished High School	0.016***
	(0.003)
Smoker	-0.072***
	(0.007)
Cigarettes	-0.077***
	(0.008)
Motheris Underweight	0.006
	(0.004)
Motheris Overweight	0.002
	(0.004)
Motheris Obese	0.001
	(0.002)
Missing BMI	-0.018**
	(0.007)
N Previous abortions	-0.018***
	(0.006)
Hypertension	0.000
	(0.002)
Missing Hypertension	0.004
	(0.004)
Preclampsia	0.004
	(0.003)
Missing Preclampsia	0.004
	(0.004)
Eclampsia	0.000
	(0.001)
Missing Eclampsia	0.004
	(0.004)
Male	0.007
	(0.007)

#Comparison adjusts for women’s age and child´s year of birth. Robust standard errors in parentheses.
* p<0.1, ** p<.05, *** p<.0