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SELF-SELECTION, PRENATAL CARE, AND BIRTHWEIGHT AMONG BLACKS, WHITES AND HISPANICS IN NEW YORK CITY

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ABSTRACT

Most research on birth outcomes has found a direct relationship between appropriate prenatal care and increased birthweight. Researchers concede, however, that without a randomized design, which is clearly unethical, one cannot determine how much of the association is due to the medical intervention and how much is due to the characteristics of the women receiving the care. In short, the degree of selection bias is unknown and potentially substantial. In this paper we test for selection bias and estimate its direction and magnitude. We find that adjusted mean differences in birthweight between women who obtain intermediate as opposed to inadequate prenatal care substantially underestimate the effects of care that would be observed under random assignment. In particular, ordinary least squares estimates indicate that the gains to intermediate care are 113 grams for black infants, 76 grams for white infants and 92 grams for Hispanic infants. Under random assigment, black infants would experience gains of 130 grams, whites 234 grams, and Hispanics 183 grams. The gains for adequate as opposed to intermediate care are relatively minor. The results point to adverse selection in the demand for prenatal care.

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Introduction

Most research on birth outcomes has found a direct association between adequate prenatal care and increased birthweight or inadequate prenatal care and low birthweight.[1] Most researchers concede, however, that without a randomized design, which is clearly unethical, one cannot determine how much of the association is due to the medical intervention and how much is due to the characteristics of the women receiving the care. In short, the degree of selection bias is unknown and possibly substantial.

To minimize the likelihood of selection bias, researchers have used multivariate analysis to control for the characteristics or behavior of women that are associated with birthweight, but also associated with the consumption of prenatal care. Data on some factors, however, are not available, whereas other variables are unobserved or inherently difficult to measure. For instance, data on nutritional intake and substance abuse are not readily available and often suspect when they are. Stress is another example. Women who obtain late or inadequate care may live in relatively stressful situations with few compensating assets. Yet instruments for assessing stress are difficult to construct and vary greatly.

Recently, economists have employed two-stage least squares or instrumental variable techniques to limit the bias due to adverse selection (Rosenzweig and Schultz 1983,1988; Corman, Joyce, and Grossman 1987). The argument is that women form expectations on the likelihood of a favorable pregnancy and birth outcome. The expectations may be based on many factors but prominent among them would be their own reproductive histories or those of their family. Put differently, women have some knowledge of their health endowment which is generally unobservable to the researcher. The health endowment not only affects the pregnancy and birth outcome, but it

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[1]The literature on prenatal care is voluminous. For recent and excellent reviews of the literature see Institute of Medicine (1985, 1988) and the U.S. Congress, Office of Technology Assessment (1988).

conditions a woman's behavior during the pregnancy. Thus, women who anticipate a problematic pregnancy and birth are more likely to initiate prenatal care earlier. As a result, estimates of the effect of prenatal care obtained from regressions that do not correct for the interaction between the use of care and the unobserved health endowment will underestimate its impact on birth outcomes. Studies in which researchers attempted to correct for adverse selection show considerably larger effects of prenatal care on birthweight than estimates unadjusted for adverse selection.

Adverse selection in input use, however, is only one source of potential bias. In the infant health literature, it is often argued that favorable selection may be a more serious source of confounding (Gortmaker 1979; Institute of Medicine 1985; U. S. Congress: Office of Technology Assessment 1988). The efficacy of prenatal care, for instance, may be overstated if adequate prenatal care is but one form of healthy behavior. As mentioned previously, the absence of such hard-to-measure inputs such as stress, nutrition, and substance abuse may bias upwards the estimated effect of prenatal care.

The present study extends the literature on prenatal care and birthweight in several ways. First, it provides a more general test of whether the effect of prenatal care on birthweight is distorted by selection bias and if so, whether favorable selection or adverse selection dominates. Second, it exploits the ordered nature of the prenatal care variable in the correction for sample selection. Third, it decomposes the gains to prenatal between what would be observed under random assignment and what is due to the unobserved characteristics specific to women who choose a particular level of care.

Analytical and Statistical Framework

Economic models of infant health emphasize the distinction between the health production function and the input demand function (Rosenzweig and

Schultz 1983; Corman, Joyce, and Grossman 1987). The former represents the technical relationship between the birth outcome and the health inputs whereas the latter focuses on the factors which determine the use of the health inputs. To illustrate, let B represent infant health and let M be a health input such as prenatal care.

$$B = B(M,D,T,E,h,\mu) \qquad (1)$$

$$M = M(E,P,Y,\mu,r) \qquad (2)$$

To complete the model, let E be schooling, let D capture demographic factors such as age and marital status, and let T stand for obstetrical elements such as the sex of the child, the plurality of the birth, and parity; let P represent price or availability measures, and let Y embody enabling variables such as income and health insurance. The lower case letters represent the unobservables. Specifically, let μ be a woman's reproductive capability or health endowment; let r be a risk aversion factor in which women with low tolerance for uncertainty seek high levels of care in order to minimize the possibility of an adverse birth outcome; and finally, let h represent unmeasured healthy behaviors.

Two features deserve note. First, the interaction between M, μ, and r as well as the absence of h in equation (1) can bias the estimated effect of M on B. A good deal of empirical work in the economic literature has focused on adverse selection -- the interaction between M and μ (Rosenzweig and Schultz 1983).[2] The second feature is that availability (P) and income (Y) measures have no direct effect on the birth outcome, but operate on infant health through their impact on M. This is an important theoretical

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[2] Explicit attempts to deal with interaction between M and h are less common. In a recent exception Grossman and Joyce (1990) estimate a birthweight production function which selects on the pregnancy resolution decision. They find that the potential mean birthweight of women who aborted was less than the observed mean birthweight of women who gave birth. The present paper ignores the impact of pregnancy resolution on birthweight and focuses on the prenatal care decision among women who give birth.

restriction that distinguishes the economic model of infant health from those estimated by other social scientists and epidemiologists. It also has important empirical implications since the availability and income measures provide a potential source of instruments with which to obtain unbiased treatment effects.

Given the prominent role of unobserved factors in equations (1) and (2), a switching regression model with endogenous switching is used to estimate the effect of prenatal care on birthweight in equation (1) [Maddala 1983]. Four equations are estimated. The first sorts women based on their level of care as characterized by a modified Kessner index. The other three are the care-specific birthweight equations. The empirical model can be expressed as follows:

$$B_{ci} = X_i\beta_c + e_{ci} \qquad (3)$$

$$I_i = Z_i\gamma + u_i \qquad (4)$$

Let B_{ci} be the birthweight of infants born to women who selected the c^{th} category of care and let I_i be a polychotomous indicator that equals 0, 1 or 2 depending on whether a woman obtained inadequate, intermediate, or adequate care respectively, as measured by a modified Kessner index. Z_i and X_i are the vector of regressors in the prenatal care and birthweight equations respectively; β_c and γ are the relevant vectors of coefficients while u_i and e_{ci} are the set of residuals. Heckman's (1979) insight was that the non-random nature of the residuals in each of the birthweight equations could be corrected by including a term for their conditional expectations. He proposed a two-stage procedure. In the first stage, the estimated parameters from the prenatal care equation (equation 4) are used to construct the relevant correction factors. In the second stage, correction factors (λ_{ci}) are inserted as separate regressors in each of the three care-specific birthweight equations.[3]

To measure the impact of adequate prenatal care on birthweight it is useful to compare the observed mean birthweight of women who receive adequate care (B_A) with the expected mean birthweight of these same women had they received intermediate ($B_I|I=2$) or inadequate care ($B_N|I=2$).[4] For example, the expected increase in birthweight for women who receive adequate care as opposed to intermediate care is the difference in the estimated birthweight equations for the respective levels of care evaluated at the mean characteristics of women who received adequate care (X_A)

$$(B_A - (B_I|I=2) = (\beta_A - \beta_I)X_A + (\beta_{\lambda A} - \beta_{\lambda I})\lambda_A \qquad (5)$$

Similarly, the gains to adequate as compared with inadequate care can be approximated as follows:

$$(B_A - (B_N|I=2) = (\beta_A - \beta_N)X_A + (\beta_{\lambda A} - \beta_{\lambda N})\lambda_A \qquad (6)$$

where $\beta_{\lambda A}$, $\beta_{\lambda I}$, and $\beta_{\lambda N}$ are the scaler coefficients on the correction factors λ_A, λ_I, and λ_N.

The primary advantage to the statistical framework is that the gains to care can be decomposed between the gains that would be observed under random assignment and the gains that are due to self-selection. For instance, since β_A, β_I, and β_N are unbiased estimates of how variations in observed characteristics affect birthweight, the first term on the right-hand-side of the equal sign in equations (5) and (6) measures the increase in birthweight that would be observed if women with mean characteristics X_A had been randomly assigned to the different levels of care. This should be viewed as the treatment effect of prenatal care. The second term on the right-hand-side of the equal sign estimates the impact of self-selection, or the gains

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[3] The model estimated here differs from Heckman's original framework in that the criterion function is polychotomous as opposed to dichotomous and the categories are clearly ordered.

[4] See Maddala (1983, pp. 261-262) for a more detailed explanation.

specific to women who obtained adequate (I=2) care due to unobserved factors particular to these women. Since the correction factor (λ_A) is positive, the effect of self selection is determined by the difference in the coefficients on the correction factors ($\beta_{\lambda A}$, $\beta_{\lambda I}$, and $\beta_{\lambda N}$).

Another advantage of the statistical model is that comparison of the two components on the right-hand-side of equations (5) and (6) with estimates obtained by ordinary least squares (OLS) uncorrected for selectivity bias offers evidence as to whether favorable selection or adverse selection is the dominant source of bias. For example, under adverse selection, women with less favorable potential birth outcomes obtain the most care. As a result OLS will underestimate the gains that would be observed had these same women been randomly assigned to the three levels of care. In the case of favorable selection, women less likely to need adequate prenatal care are the ones most likely to obtain it. These are women whose birth outcomes would be favorable irrespective of care due to their general health and behavior during pregnancy. If favorable selection is primary, then OLS will overestimate the gains to adequate prenatal care relative to what would be observed under random assignment.

The second term on the right-hand-side of the equal sign in equations (5) and (6) -- the difference in the coefficients on the corrections factors -- measures the gains to self-selection. If the difference is positive, then the women who select adequate care benefit more from such care than would a randomly chosen woman with the same observed characteristics. Put differently, pregnant women sort themselves optimally. A negative difference would suggest the opposite. One could speculate as to the dominant unobservables most consistent with a positive or negative difference, but to statistically identify the dominant unobservable would require strong assumptions as to the correlations among the unobservables as well as their relative impact on care-specific birthweight.

Data and Empirical Specification

Data are from New York City vital statistics in 1984. The analysis pertains to the entire resident population of white non-Hispanic, black non-Hispanic and Hispanic women 20 years and older who gave birth in 1984.[5] In that year there were over 105,000 live births to New York City residents. The three groups in this study represent almost 83 percent (N=87,470) of all live births in that year. Because of missing data the actual number used in the analysis was somewhat smaller (N=79,915).

The vital statistics were augmented with 1980 census data that had been aggregated up from the census tract to the health area level. The health area is the smallest geographical unit identified on the birth certificate. There are 352 health areas in New York City and the average one contains between 15,000 and 25,000 residents. From the census data we calculated the race- and ethnic-specific percentage of persons below the poverty level in each health area.

The availability of health services were also matched to health areas. Specifically, we added the number of prenatal care clinics and family planning clinics by health area in 1983 per 10,000 women 15 to 44 years of age. The denominators were from the 1980 census. An additional availability measure was a dichotomous variable that equaled 1 if a woman lived in a health district serviced by a site of the Supplemental Program for Women, Infant, and Children (WIC). There are 30 health districts in New York City. Each contains approximately 10 health areas.

Missing data were not considered a major problem. Eleven percent of the black births, 6 percent of the Hispanic births, and 8 percent of the white

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[5] Adolescents were excluded in order to lessen the potential endogeneity of such factors as marital status, schooling, and Medicaid. The decision to give birth, especially among adolescents, may be determined simultaneously with the decision to complete school, apply for Medicaid, or to get married. The endogeneity of these factors should be less relevant among adults. See Grossman and Joyce (1990) for a more detailed discussion.

births were dropped due to missing information on age, parity, education, method of finance, type of service, health area of residence and the mother's country of birth. Missing data on when prenatal care began and the number of visits were included as part of the modified Kessner index. A more detailed breakdown is available upon request.

Prenatal care is measured by a modified Kessner index (Institute of Medicine 1973).[6] The index combines the trimester in which care began with the number of visits adjusted for gestation. The index yields three levels of care: adequate, intermediate, and inadequate. The level of prenatal care is determined by mother's education, health area poverty rates, the availability of health services, whether the mother was foreign born and the method of finance which has three categories: Medicaid, self pay or some other third party.

Birthweight is measured in grams. Infants less than 500 grams were excluded. The birthweight specification includes measures of age, marital status, parity, sex, plurality, type of delivery, mother's education, whether the mother was foreign born, and dichotomous measures of whether the pregnancy and birth were complicated by illegal drugs and tobacco. The indicators of drug use and tobacco come from the confidential portion of the birth certificate and are self reported or are based on the assessment of a physician or midwife. Table 1 presents the means and frequencies by race, ethnicity and by the level of prenatal care.

An ordered probit is used to estimate the level of prenatal care. The dependent variable is zero if care were inadequate, one if intermediate, and two if adequate. The results from the first stage are used to construct the correction factors which are then inserted into the respective birthweight

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[6] The modification excludes whether the birth was a private service or general service delivery. The type of delivery, however, is included as a separate regressor in the birthweight equations.

equations. The birthweight equations are estimated by ordinary least squares and the standard errors are adjusted following Heckman (1979) and Greene (1981, 1990) Appropriate modifications are made to account for the ordered nature of the prenatal care measure.[7]

[7] See the Appendix for the appropriate correction factors. A detailed description of the variance-covariance matrixes as derived by William Greene is available upon request.

Results

The results are organized as follows: Table 2 presents estimates from the ordered probit for the three racial and ethnic groups. Tables 3, 4, and 5 show the care-specific birthweight equations for blacks, whites, and Hispanics respectively. Table 6 summarizes the effect of prenatal care on birthweight for each of the three groups and compares the estimates corrected for self-selection with those uncorrected for selection.

Interpretation of the coefficients from the ordered probit is unambiguous only for changes in the likelihood of inadequate care ($I_i=0$) or adequate care ($I_i=2$) (Greene 1990). To understand how each of the variables affects the likelihood of intermediate care is not obvious from the coefficients.[8] Women who lack insurance (self pay) are more likely to obtain inadequate care than are women covered by some other third party (the omitted category). Similarly, women with less than a high school education are less likely to obtain adequate care relative to women who graduated from high school.

The same interpretation applies to continuous variables. Local area poverty rates are associated with increases in the probability of inadequate care while the availability of prenatal care clinics has the opposite effect. The impact of a WIC center in a health district is less consistent and the presence of family planning clinics is associated with a decreased likelihood of adequate care. The latter results are not unexpected since WIC and family planning clinics are often targeted at high-need areas. Many of the prenatal care clinics, however, are affiliated with a local hospital, and thus, their placement is often determined by the catchment area of the hospital.

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[8] In the case of dummy variables one must compute the changes in the cumulative density function for the different levels of care holding constant the other characteristics. When the variable is continuous, the density as well as the cumulative function must be computed. See Greene (1990) for an illustration.

The effect of a change in education on the likelihood that a woman will obtain intermediate care is less apparent. For instance, an increase in completed schooling from less than 12 years to 12 years raises the probability that a black woman will obtain an intermediate level of care by 11 percentage points (from 43.6 to 54.6) while simultaneously lowering the likelihood of adequate and inadequate care.[9] Yet for whites and Hispanics, a similar change lowers the likelihood that a woman will obtain intermediate or inadequate care and raises the probability of adequate care. Similarly, among whites and Hispanics, private insurance lowers the likelihood of intermediate or inadequate care relative to women who are uninsured, but it raises the likelihood of intermediate care for blacks.

The results from the birthweight equations in Tables 3, 4 and 5 generally conform to the literature. Marital status, parity, plurality, and the sex of the newborn have the expected signs. Except for blacks, schooling is not a reliable predictor of birthweight and even among blacks the size of the coefficient is relatively small. The drug use and tobacco measures have the anticipated sign, except in the case of white women with adequate care, and the coefficient on the tobacco measure is close to the 150-250 gram interval that has been found in a wide range of studies with more refined measures of smoking (Stein and Kline 1983).

Comparison of coefficients across levels of care reveals a notable gradient from inadequate to adequate care for some regressors. The impact of illegitimacy on birthweight, for instance, increases in absolute value as the level of care diminishes. This is true for all three groups. A similar pattern persists for smoking and the mother's country of origin. Women born outside the United States, for example, have heavier children than similar

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[9] This example refers to women born in the U.S., who are on Medicaid, and who live in a health district that has a WIC center. The continuous variables were evaluated at their means. Among Hispanics, the example refers to Puerto Ricans.

women who were born in the U.S, but the differences decline as the level of care increases.

The presence of selection bias is determined by the coefficient on the correction factor. The estimates in Table 3, 4 and 5 reveal that the null hypothesis of no selection bias can be rejected among women who obtain an intermediate level of prenatal care. Given the number of births that were analyzed, rejection of the null hypothesis is not an overly impressive result. The magnitude and the interpretation of the coefficient on the correction factor, however, offer a number of insights as to the nature of the selection bias and its relative impact. The coefficient on the correction factor is the covariance between the residuals in the prenatal selection equation and the residuals in the relevant birthweight equation. Among Hispanics, therefore, women who have a greater than expected probability of intermediate care have infants with less than expected birthweight (Table 5). Moreover, excluding plurality, only smoking has a larger impact on birthweight. The interpretation of the coefficients on the correction factors is the same among black and white women who received an intermediate level of care, but the magnitude of the effect is smaller.

The most useful way to assess the impact of prenatal care on birthweight is to compare the observed mean birthweight of women who obtained adequate with the expected mean birthweight of these same women had they received inadequate or an intermediate level of care. Also displayed are the gains from inadequate to intermediate care for women who obtained an intermediate level of care. As described by equations (5) and (6), this assessment can be decomposed into the effect of care that would be observed under random assignment and the effect that is due to self selection. The results are displayed in Table 6. For each race and ethnic group, column one shows the change in birthweight from intermediate as opposed to inadequate prenatal care. Column two shows the gains in birthweight moving from an intermediate to an adequate level of care. And column three displays the gains from inadequate to adequate care. Comparison by row contrasts the gains as estimated by OLS uncorrected for selection (row one) with the gains that would be realized under random assignment (row two), and the gains specific to women who chose a particular level of care -- that is, the gains to self selection (row three).

Three points merit attention. First, the greatest gains are realized when women move from an inadequate to intermediate level of care (column one, row 2). The changes from inadequate to adequate care are dominated by the change from inadequate to intermediate care. Second, for blacks and Hispanics the effects of self-selection (row 3) are greatest for the women who received adequate care. Third, comparison of rows one and two for each race and ethnicity indicates that OLS underestimates the gains in birthweight that would be observed if self selection were not a factor -- in other words -- if women were randomly assigned to a level of prenatal care. The magnitude of the bias is relatively minor among blacks. Among Hispanics and whites, however, OLS underestimates the gains to care by a factor of 2 and 3 respectively.

The downward biased estimates yielded by OLS points to adverse selection in the demand for prenatal care. Women who anticipate a problematic pregnancy seek higher levels of care than similar women with more favorable expectations. The response by pregnant women to these unobserved factors accounts for the non-random nature of the prenatal care decision and thus, the biased estimates obtained by OLS.

The gains to self-selection (row 3) reflect the increase in birthweight due to the unobserved characteristics associated with the women who seek out that particular level of care. For instance, if Hispanic women were randomly assigned to the three levels of care, we would observe a 47 gram difference between women who received an adequate as opposed to an intermediate level of care. However, Hispanic women who actually obtain adequate care realize gains of 165 grams because of unmeasured factors associated with the decision to seek out that level of care. One can only speculate as to the unmeasured factors responsible for such gains. It may be that Hispanics who obtain adequate care may be more knowledgeable as to the factors associated with a healthy pregnancy and may have greater motivation to adhere to these healthy behaviors than their counterparts who sought out less adequate care. Regardless of the underlying factors, with one exception self-selection is positively related to birthweight although the magnitude of the effect is less among blacks and whites.

Discussion

We used a modified Kessner index to estimate the impact of prenatal care on the entire population of black, white, and Hispanic adult women who were residents of New York City in 1984. The results confirm, as many researchers have suspected, that women who obtain more appropriate care differ in unmeasured ways from similar women who acquire less appropriate care. As a result, previous estimates of the gains to prenatal care which make no attempt to correct for self selection may underestimate its effect on birthweight. In addition, we found that the underestimation was greatest when women who obtained intermediate care were compared to women whose care was inadequate. The gains from intermediate to adequate care were substantially smaller.

The results point to adverse selection as opposed to favorable selection as the dominant source of bias. The direction of the bias is consistent with other econometric studies that have used two-stage least squares (TSLS) to control for adverse selection (Rosenzweig and Schultz 1983, 1988; Corman, Joyce, and Grossman 1987; Joyce 1987).[10] Rosenzweig and Schultz (1988) used the 1980 National Natality Survey and found that a one month delay in the initiation of prenatal care lowered birthweight by 4 grams when estimated by OLS and by 91 grams when estimated by TSLS. Assuming the impact to be linear, the delay of a trimester would yield a loss of 273 grams. This is close to the gains experienced by whites who obtain intermediate as opposed to inadequate care reported in this study. Although the other study used the rate of low birthweight as the dependent variable, the coefficient on prenatal care rose by a factor of 3 in absolute value when TSLS estimates were compared with estimates obtained by OLS (Joyce 1987).

Comparison of the gains to care reported here and those from one of the earliest studies of New York City birth certificates by the Institute of Medicine (1973) underscores the detrimental effect of inadequate care and deemphasizes the importance of adequate as opposed to intermediate care. The Institute of Medicine reported that the mean difference in birthweight between women who obtained adequate as opposed to intermediate care, holding constant socioeconomic as well as medical and obstetric risk factors, averaged only 16 grams across all five racial and ethnic groups (Institute of Medicine 1973, Table A-4). Yet the mean difference in birthweight averaged almost 100 grams when women who received intermediate care were compared to women who obtained inadequate care.

Recent evaluations of the selectivity bias correction methodology in the economic literature suggest that selection effects are not overly

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[10] Other evidence suggestive of adverse selection comes from Harris (1982) who hypothesized that women who initiate care in the third trimester have inherently more viable fetuses for no other reason than the duration of their pregnancy. His empirical work, based on births to black women in Massachusetts, suggests that estimates of the effect of prenatal care on gestation that make no attempt to control for fetal viability are biased downwards. The magnitude of the effect was not large, but Harris notes that women who suspect their fetuses are less healthy may initiate prenatal care earlier as a preventive measure.

sensitive to the assumptions of normally distributed errors (Newey et al. 1990). Rather, variation in estimates across different studies of labor supply were more sensitive to the set of regressors in both the selection equation as well as the primary equation of interest (Mroz 1987). In this regard, the restrictions imposed by the economic model of infant health strengthen the empirical specification since the production function is clearly distinguished from the prenatal care demand function. Variables like the sex of the child and the plurality of the birth, for instance, are strictly exogenous to the prenatal care decision, while the measures of poverty and health insurance are enabling variables that operate on birthweight through the utilization of the health inputs. Mother's education, on the other hand, has a theoretical justification in both equations (Grossman 1972; Rosenzweig and Schultz 1982). To test the sensitivity of the results to the inclusion of mother's education in the birthweight equation, we excluded it from the birthweight specification. The results were unchanged. Because of possible measurement error, we excluded the indicators of tobacco and drug use from the birthweight equation. Again, the results were essentially unchanged, except for modest increases in the selection effects. Finally, results did not change appreciably if the natural log of birthweight was used as the dependent variable.

The policy implications are straightforward. Although the results suggest that there are diminishing returns to more appropriate care, the marginal gains to an intermediate level care appear substantial. Thus, the most cost-effective approaches at improving birth outcomes through the expanded utilization of prenatal care will be the ones that motivate women who would have received late or no care, to begin care in the second trimester and to continue care to birth. The study also finds that the incremental gains to adequate care among black and Hispanic women are much less than the gains associated with self-selection. Put differently, the unobserved characteristics associated with the women who secure adequate as opposed to intermediate care are relatively large and positively related to birthweight.

This study remains exploratory. A better specified birthweight equation may reduce the selection effects. More refined data on smoking, substance abuse, maternal weight gain, as well as richer measures of prenatal care may control for the unobserved healthy behaviors modeled above. The methodology should also be applied to different data on birth outcomes. Nevertheless, population heterogeneity insures that even if such unobserved factors as the health endowment are randomly distributed among the population, as long as these elements are known to the individual, but not to the researcher, then the potential for selectivity bias will remain.

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Appendix

As described by equations (3) and (4) in the text, the model can be specified as follows:

$$B_{ci} = X_i\beta_c + e_{ci}$$

$$I_i = Z_i\gamma + u_i$$

Thus, the expected birthweight of women who receive adequate care (B_A), intermediate care (B_I), and inadequate care (B_N) can be written as follows:

$$E\ (B_{ci}|X_i,\ I_i = 2) = B_{Ai} = X_i\beta_A + \beta_{\lambda A}\lambda_{Ai}$$

$$E\ (B_{ci}|X_i,\ I_i = 1) = B_{Ii} = X_i\beta_I + \beta_{\lambda I}\lambda_{Ii}$$

$$E\ (B_{ci}|X_i,\ I_i = 0) = B_N = X_i\beta_N + \beta_{\lambda N}\lambda_{Ni}$$

where

$$\lambda_{Ai} = \frac{\phi(\mu - Z_i\gamma)}{1 - \Phi(\mu - Z_i\gamma)}$$

$$\lambda_{Ii} = \frac{\phi(-Z_i\gamma) - \phi(\mu - Z_i\gamma)}{\Phi(\mu - Z_i\gamma) - \Phi(-Z_i\gamma)}$$

$$\lambda_{Ni} = \frac{-\ \phi(-Z_i\gamma)}{\Phi(-Z_i\gamma)}$$

and where $\beta_{\lambda A} = \frac{\sigma_{e_A u}}{\sigma_u}$, $\beta_{\lambda I} = \frac{\sigma_{e_I u}}{\sigma_u}$, and $\beta_{\lambda N} = \frac{\sigma_{e_N u}}{\sigma_u}$

Note ϕ represents the density function and Φ is the cumulative density function of the standard normal. The numerator is the covariance of the residuals in the care-specific birthweight equation with the residuals from the ordered probit and the denominator is a positive scale factor.

The variance-covariance matrix is the usual one when I=0, (Greene 1990, pp. 743-744), but it has a more complicated form when I=1 or I=2. A more detailed description as derived by William Greene is available upon request.

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Table 1

Means and Frequencies by Level of Care

	Blacks			Whites			Hispanics		
	Adeq	Inter	Inadeq	Adeq	Inter	Inadeq	Adeq	Inter	Inadeq
Birthweight	3188	3167	3015	3371	3372	3225	3317	3278	3134
Unmarried	.45	.56	.69	.05	.09	.29	.35	.44	.58
Education									
Schooling < 12 yrs	.15	.25	.36	.05	.10	.26	.33	.42	.54
Schooling = 12 yrs	.44	.29	.44	.42	.41	.49	.43	.16	.36
Schooling > 12 yrs	.41	.46	.20	.53	.50	.25	.24	.42	.10
Method of Finance									
Medicaid	.32	.48	.64	.04	.12	.31	.44	.56	.64
Self pay	.05	.08	.11	.08	.09	.19	.07	.08	.09
Other 3rd party	.63	.44	.25	.88	.79	.50	.49	.37	.27
Foreign born mother	.39	.38	.28	.20	.24	.34	.72	.74	.72
Mother's age	28	27	26	29	28	28	28	27	26
Private service delivery	.55	.33	.17	.92	.82	.40	.44	.27	.10
Sex (male=1)	.51	.50	.50	.51	.52	.53	.50	.51	.51
Plural birth	.03	.03	.02	.02	.02	.02	.02	.02	.02
Parity									
No previous live births	.40	.36	.32	.55	.43	.37	.37	.34	.33
1-3 live births	.55	.57	.56	.42	.50	.53	.59	.60	.58
4 or more live births	.05	.07	.12	.03	.07	.10	.04	.06	.09
Drugs complicated preg.	.02	.01	.05	.02	.02	.05	.02	.01	.04
Tobacco complicated preg.	.03	.06	.10	.02	.02	.04	.03	.04	.06
% poor in health area	27	29	32	11	14	17	34	37	41
Prenatal clinics/women	.87	.94	1.00	.63	.67	.70	.87	.83	.92
Fam. plan. clinics/women	1.22	1.36	1.50	.73	.76	.88	1.41	1.42	1.72
Abortion prov./women		.55			.59		.72	.58	.61
WIC cntr in health dist.	.52	.53	.56	.25	.30	.37	.41	.43	.47
Hispanic descent									
Puerto Rican	-	-	-	-	-	-	.51	.49	.57
Mexican	-	-	-	-	-	-	.02	.02	.02
Cuban	-	-	-	-	-	-	.03	.02	.01
Cent/So. American	-	-	-	-	-	-	.37	.41	.35
Other Hispanic	-	-	-	-	-	-	.07	.06	.05
Number of observations	6486	13490	5649	15142	12312	1531	6417	14133	4752

Table 2

Ordered Probit Estimates of Prenatal Care *

	Blacks	Whites	Hispanics
Constant	1.2097	1.9191	1.4060
	(48.16)	(95.31)	(47.67)
Schooling < 12 yrs.	-0.2023	-0.3024	-0.1460
	(-11.19)	(-11.68)	(-9.06)
Schooling > 12 yrs.	0.1490	0.2030	0.1906
	(8.79)	(13.38)	(8.96)
Medicaid	-0.4554	-0.5792	-0.2029
	(-27.85)	(-22.67)	(-12.32)
Self pay	-0.5811	-0.3190	-0.2641
	(-21.43)	(-13.58)	(-9.64)
Foreign born	0.0616	-0.1060	0.0023
	(3.87)	(-6.33)	(0.13)
% poor in hlth area	-0.0055	-0.0119	-0.0092
	(-9.08)	(-14.32)	(-15.20)
Prenatal clinics/women	0.0130	0.0331	0.0112
	(1.71)	(3.35)	(1.51)
Fam. plan. clinics/women	-0.0151	-0.0307	-0.0086
	(-2.76)	(-3.76)	(-1.94)
WIC cntr in health dist.	0.0367	-0.0305	0.0203
	(2.48)	(-1.86)	(1.34)
Abortion providers/women	0.0038	-0.0021	0.0201
	(0.51)	(-0.32)	(2.91)
Mexican			-0.0820
			(-1.61)
Cuban			0.1723
			(2.95)
South American			-0.0310
			(-1.73)
Other Hispanic			0.0056
			(0.18)
Threshold parameter mu	1.5173	1.6738	1.5996
	(140.26)	(119.73)	(144.79)
Log likelihood	-24997.	-23688.	-24346.

* The dependent variable is coded 2 if a woman received adequate care, 1 if intermediate, and 0 if inadequate. The omitted categories for education and method of finance are 12 years of schooling and other third party respectively.

Table 3

Ordinary Least Squares Estimates of Black Birthweight Equations Corrected for Self Selection For Women Who Received Adequate, Intermediate and Inadequate Care*

	Adequate	Intermediate	Inadequate
Constant	3405	3322	3994
	(16.35)	(25.05)	(17.05)
Unmarried	-31	-52	-117
	(1.95)	(4.59)	(5.69)
Schooling < 12 yrs.	-44	-10	-25
	(1.86)	(0.72)	(1.12)
Schooling > 12 yrs.	41	32	56
	(2.44)	(2.44)	(2.28)
Foreign born	58	87	144
	(3.83)	(7.80)	(6.78)
Mother's age	-21	-12	-66
	(1.60)	(1.32)	(4.15)
Age sq.	0	0	1
	(1.75)	(1.23)	(3.92)
Private service delivery	7	29	27
	(0.39)	(2.33)	(1.12)
Sex (male=1)	174	120	73
	(12.61)	(12.17)	(4.27)
Plural birth	-793	-830	-873
	(19.53)	(26.55)	(14.67)
First live birth	-38	-65	-40
	(2.46)	(5.78)	(2.06)
4 or more births	26	15	16
	(0.77)	(0.74)	(0.56)
Drugs complicated preg.	-75	-111	-116
	(1.17)	(2.31)	(1.30)
Tobacco complicated preg.	-140	-166	-166
	(3.37)	(7.89)	(5.55)
Correction factor (λ)	-4	-61	-19
	(0.09)	(2.13)	(0.35)
F-statistic	43.88	86.21	31.61
Adjusted R-squared	0.085	0.081	0.071

* Birthweight is measured in grams. Absolute value of t-statistics are in parentheses. The omitted categories are as follows: 12 years of schooling in case of education, other third party with respect to the method of finance, and 1-3 previous live births in the case of parity.

Table 4

Ordinary Least Squares Estimates of White Birthweight Equations Corrected for Self Selection For Women Who Received Adequate, Intermediate, and Inadequate Care *

	Adequate	Intermediate	Inadequate
Constant	3391	3404	3783
	(23.86)	(24.62)	(9.26)
Unmarried	-79	-93	-121
	(3.78)	(5.23)	(3.10)
Schooling < 12 yrs.	-8	12	16
	(0.34)	(0.65)	(0.34)
Schooling > 12 yrs.	8	22	107
	(0.74)	(1.875)	(2.46)
Foreign born	3	36	108
	(0.24)	(3.11)	(3.03)
Mother's age	-2	-7	-54
	(0.18)	(0.77)	(1.92)
Age sq.	0	0	1
	(0.16)	(0.64)	(1.98)
Private service delivery	36	16	94
	(2.11)	(1.14)	(2.69)
Sex (male=1)	118	128	128
	(14.09)	(13.92)	(4.25)
Plural birth	-842	-828	-695
	(30.73)	(23.94)	(6.53)
First live birth	-72	-53	-153
	(8.00)	(5.26)	(4.59)
4 or more births	-5	50	71
	(0.20)	(2.53)	(1.28)
Drugs complicated preg.	-62	50	-9
	(2.18)	(1.57)	(0.08)
Tobacco complicated preg.	173	-83	-90
	(5.68)	(2.53)	(1.13)
Correction factor (λ)	-41	-55	-84
	(1.10)	(2.23)	(1.24)
F-statistic	88.23	62.08	10.17
Adjusted R-squared	0.075	0.065	0.077

* Birthweight is measured in grams. Absolute value of t-statistics are in parentheses. The omitted categories are as follows: 12 years of schooling in case of education, other third party with respect to the method of finance, and 1-3 previous births in the case of parity.

Table 5

Ordinary Least Squares Estimates of Hispanic Birthweight Equations Corrected for Self Selection For Women Who Received Adequate, Intermediate and Inadequate Care *

	Adequate	Intermediate	Inadequate
Constant	2960	3088	2784
	(14.42)	(25.25)	(10.90)
Unmarried	-46	-46	-104
	(2.95)	(4.73)	(5.56)
Schooling < 12 yrs.	-25	0	-5
	(1.32)	(0.04)	(0.24)
Schooling > 12 yrs.	-12	-3	-5
	(0.61)	(0.21)	(0.16)
Foreign born	20	30	75
	(1.12)	(2.31)	(3.32)
Mother's age	19	8	16
	(1.45)	(0.96)	(0.99)
Age sq.	0	0	0
	(1.33)	(1.00)	(0.99)
Private service delivery	16	37	76
	(0.99)	(3.27)	(2.59)
Sex (male=1)	144	121	82
	(10.61)	(13.38)	(4.74)
Plural birth	-797	-840	-1115
	(17.91)	(25.73)	(18.34)
First live birth	-65	-84	-20
	(4.26)	(8.05)	(1.00)
4 or more births	36	25	-26
	(1.03)	(1.18)	(0.79)
Drugs complicated preg.	-45	-26	-84
	(0.78)	(0.63)	(0.84)
Tobacco complicated preg.	-80	-148	-189
	(2.01)	(6.46)	(5.05)
Correction factor (λ)	2	-133	-65
	(0.03)	(3.61)	(0.86)
Mexican	34	83	15
	(0.64)	(2.56)	(0.26)
Cuban	56	21	58
	(1.24)	(0.54)	(0.63)
South American	89	95	92
	(5.25)	(7.96)	(4.20)
Other Hispanic	84	90	72
	(3.09)	(4.41)	(1.74)
F-statistic	30.00	67.00	30.62
Adjusted R-squared	0.075	0.077	0.101

* Birthweight is measured in grams. Absolute value of t-statistics are in parentheses. The omitted categories are: 12 years of schooling in case of education, other third party with respect to the method of finance, 1-3 previous births in the case of parity, and Puerto Ricans with respect to Hispanics.

Table 6

Expected Mean Increase in Birthweight Due to Changes in the Level of Prenatal Care*

Changes from....	inadequate to intermediate	intermediate to adequate	inadequate to adequate
		Blacks	
OLS	113	0	113
RANDOMIZATION	130	14	144
SELF-SELECTION	2	68	18
		Whites	
OLS	76	3	79
RANDOMIZATION	234	74	287
SELF-SELECTION	-19	10	31
		Hispanics	
OLS	92	29	122
RANDOMIZATION	183	47	215
SELF-SELECTION	6	165	82

*The expected changes from intermediate to adequate care and from inadequate to adequate care are based on equations (5) and (6) in the text respectively. The analogous change from inadequate to intermediate care is as follows:

$$(B_I - (B_N|I=1) = (\beta_I - \beta_N)X_A + (\beta_{\lambda I} - \beta_{\lambda N})\lambda_I \qquad (7)$$

Note the mean characteristics, X_A, are used to make the results more comparable. The OLS estimates come from the first term on the right-hand-side of the equal sign in equations (5)-(7) except that the parameter vectors are based on the regressions uncorrected for selection.