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DEMOGRAPHIC ANALYSIS OF BIRTHWEIGHT-SPECIFIC NEONATAL MORTALITY

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ABSTRACT

This paper explores the determinants of birthweight-specific neonatal mortality rates across states in the U.S. in 1980. We are able to explore the interactions between the determinants and birthweight because of the new data available through the National Infant Mortality Surveillance (NIMS). The NIMS links birth and death certificates for each state, resulting in a data base with race-specific neonatal mortality rates by birthweight, and other characteristics. Using a reduced-form model, we find abortion and neonatal intensive care availability to be the most important determinants of overall neonatal mortality. For whites, the two factors are of approximately equal importance in determining neonatal mortality. For blacks, abortion availability has twice the impact of neonatal inensive care. Moreover, our results suggest that neonatal mortality rates could be lowered by policies that reduce the inequality in these health resources across states.

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I. Introduction

Despite a rapid decline in the neonatal mortality rate between 1964 and 1985,[1] large cross-sectional differences in the rate persist. The most notable of these is the excess death rate of black babies. The black neonatal mortality rate was twice as large as the white rate both in 1964 and 1984. Moreover, the U.S. neonatal mortality rate remains relatively higher than those of a number of other developed countries even when the U.S. rate is limited to whites [U.S. Department of Health and Human Services (USDHHS) 1986].

Because of the importance of the topic, the authors have devoted considerable research effort in examining the causes of neonatal mortality.[2] Using a multivariate approach, we found that public program measures,[3] abortion, and neonatal intensive care are all important predictors of white and black birth outcomes. In addition, trends in these variables account for a substantial fraction of the decline in race-specific neonatal mortality since 1964.

In our previous research we were unable to explore potential interaction effects between the determinants of neonatal mortality and birthweight because we lacked data on birthweight-specific mortality rates. The current

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[1] Between 1964 and 1985, the rate fell by approximately 61 percent (4.4 percent per year compounded annually) from 17.9 deaths per thousand live births in the former year to 7.0 deaths per thousand live births in the latter year. [CDC and National Center for Health Statistics (NCHS) 1988].

[2] Corman and Grossman 1985; Corman, Joyce, and Grossman 1987; Joyce 1987a, 1987b; Joyce, Corman, and Grossman 1988.

[3] Public programs include: Medicaid, Maternal and Infant Care projects, Community Health Centers, the WIC program, and federally subsidized family planning services for low-income women.

project improves upon the estimates of the impacts of neonatal intensive care, public programs, abortion, and prenatal care contained in previous studies. These refined estimates shed additional light on the causes of the rapid decline in neonatal mortality since 1964. It is particularly important to gain a better understanding of the determinants of birthweight-specific neonatal mortality rates since changes in these rates appear to have accounted for a large percentage of the overall decline in neonatal mortality since 1964 (Institute of Medicine 1985; USDHHS 1986; Corman, Joyce, and Grossman 1987; Office of Technology Assessment 1988).

We are able to explore interactions with birthweight because of the new data available through the National Infant Mortality Surveillance (NIMS). As part of the NIMS project, each of the fifty states of the United States and the District of Columbia linked birth and death certificates for the year 1980. This project is the first national linkage of birth and death records in the U.S. since 1960. The end result is a state data base with race-specific neonatal mortality rates by birthweight, mother's age, and other characteristics.

II. Analytical Framework

We estimate equations that are generated from the economic model contained in Corman and Grossman (1985); Corman, Joyce and Grossman (1987); and Joyce (1987a, 1987b). It is assumed that the parents' utility function depends on their own consumption, the number of births, and the survival probability of each birth. Maximization of the parents' utility function subject to production and resource constraints generates a demand function for survival in which the survival probability or its complement, the neonatal mortality rate, is related to input prices, efficiency, income, and tastes.

In previous research we employed a structural equations model, emphasizing the roles of six basic health inputs: prenatal medical care, neonatal intensive care, maternal nutrition, maternal cigarette smoking, abortion, and contraceptive services. The equations have meaningful interpretations both at the family level and at a higher level of aggregation such as the county or the state. The model consists of structural production functions, input demand functions, and reduced form outcome equations. The structural mortality rate production function relates this outcome to the fraction of low-weight births in the state, the basic health inputs except for maternal cigarette smoking, and the biological endowment. The structural low-birth-weight production function relates the fraction of light births to maternal cigarette smoking, all health inputs in the mortality equation except for neonatal intensive care use, and the biological endowment.[4,5]

Associated with each of the inputs is a demand function that relates the use of that input to a vector of price and availability measures, socio-economic characteristics that reflect command over resources and tastes, and the biological endowment. Substituting the input demand functions into the birthweight production function yields outcome equations in which the fraction of light births or the neonatal mortality rate depends upon a vector of exogenous variables. Hence the outcome equations and the input demand functions constitute the reduced form of the model. It is the reduced form

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[4] Neonatal intensive care is excluded from the birthweight production function because decisions to use neonatal intensive care services are usually made after birth.

[5] Cigarette smoking is assumed to affect neonatal mortality only through its impact on low birthweight to satisfy rank and order conditions for identifying the model. Numerous studies summarized by the USDHHS (1980) support this restriction.

outcome equations which we estimate below. Since the reduced form outcome equations contain only exogenous variables on their right-hand sides, they can be estimated by ordinary least squares.[6]

From a practical standpoint, the difference between the structural equations and the reduced form is that the former relates birth outcomes to utilization of the health inputs whereas the latter relates birth outcomes to the availability of the inputs. The reduced form is the most helpful approach to understanding public policies related to birth outcomes for several reasons. First, the public sector can only control the availability of programs; the public sector cannot force utilization of any of the programs. Second, increasing the availability (or decreasing the price) of one health input may affect the utilization of other inputs, if they are substitutes or complements. For example, increased availability of contraceptive services may reduce the level of unwanted pregnancies, resulting in more health inputs being utilized when a pregnancy does occur. In this example, contraceptive services and prenatal care would be considered complements, since an increase in the availability of one results in increased use of the other. The health inputs may also be substitutes. For example, the increased availability of contraceptive services could reduce the use of abortion services. Only the reduced form allows for both the direct effects of the increased availability of an input on utilization of that input plus the indirect effects of increased availability through increased utilization of complements and decreased utilization of substitutes.

The reduced form model previously estimated was of the form:

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[6] For a fuller description of the relationship between the structural model and the reduced form, see Corman and Grossman(1985).

$$d = f(a,c,m,n,p,z) \quad (1)$$

where d is the neonatal mortality rate, a is the availability of abortion services, c is the availability of contraception services, m is the availability of prenatal care services, n is the availability of neonatal intensive care services, p is the availability of public programs aimed at poor pregnant women, and z is a vector of socioeconomic characteristics which reflect command over resources, tastes, and the woman's efficiency in health production. We are now able to modify the above framework to account for the interaction effects between certain important determinants of neonatal mortality and birthweight. For example, neonatal intensive care units are aimed primarily at low birthweight babies and should have larger effects on death rates of light babies than on death rates of normal weight babies.

The most direct way to take account of these interactions is to employ neonatal mortality rates classified by birthweight as the dependent variables in the estimation of the reduced form models. Allowing for two birthweight classes: light or low weight (less than 2,500 grams) and normal weight (2,500 grams or more), let d_{1j} be the neonatal death rate of light infants in the j^{th} state, let d_{2j} be the neonatal death rate of normal weight infants in the j^{th} state, and let b_j be the fraction of light births. As an identity, the non-birthweight-specific neonatal mortality rate in the j^{th} state is:

$$d_j = b_j d_{1j} + (1 - b_j) d_{2j} . \quad (2)$$

Suppress the state subscript and specify reduced form mortality equations for the two neonatal mortality rates:

$$d_1 = \alpha_0 + \alpha_1 a + \alpha_2 c + \alpha_3 m + \alpha_4 n + \alpha_5 p + \alpha_6 z + u_1 \quad (3)$$

$$d_2 = \tau_0 + \tau_1 a + \tau_2 c + \tau_3 m + \tau_4 n + \tau_5 p + \tau_6 z + u_2 \quad (4).$$

In these equations, the α coefficients reflect the effects of the availability of health inputs and socioeconomic variables on neonatal mortality rates of light infants, and the τ coefficients reflect the effects of these variables on normal weight babies. To complete the model, we can also specify a birthweight reduced form equation as:

$$b = \phi_0 + \phi_1 a + \phi_2 c + \phi_3 m + \phi_4 n + \phi_5 p + \phi_6 z + v \qquad (5).$$

Estimation of the above three equations allow us to decompose the total impact on neonatal mortality of a given determinant into effects operating through low birthweight and through birthweight-specific neonatal mortality.[1] This system underscores the utility of a data base that contains risk-specific as opposed to non-risk-specific death rates.

III. Empirical Implementation

A. Data and Measurement of Birth Outcomes

Neonatal mortality rates by race (white and black), birthweight (less than 2,500 grams, 2,500 grams or more) and by state for the year 1980 are taken from the National Infant Mortality Surveillance (NIMS). The state- and race-specific fraction of low-weight (less than 2,500 grams) live births in 1980 comes from the National Center for Health Statistics (NCHS) Natality

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[1] In the case of abortion services, suppose that a rises by one unit. Then the effect of an increase in a on the observed neonatal mortality rate is:

$$(\delta d/\delta m) = (d_1 - d_2)\phi_1 + b\alpha_1 + (1-b)\tau_1.$$

The first term on the right hand side is the effect of of prenatal care on neonatal mortality through low birthweight. The second two terms equal a weighted average of the effects of prenatal care on the mortality rates of low-weight and normal-weight infants. This weighted average represents the birth-weight-specific effect.

Tape.[8] NIMS was prepared by the Centers for Disease Control (CDC) under an interagency agreement between CDC and the National Institute of Child Health and Human Development (see Hogue et al. 1987). Under the NIMS project each of the fifty states of the U.S. and the District of Columbia linked birth and death certificates for the 1980 birth cohort. These linkages pertain to births by mother's state of residence in 1980 regardless of the state in which the subsequent infant death occurred or the infant's state of residence at death. Neonatal deaths and death rates pertain to singleton births only.

We aggregated births and neonatal deaths into two weight categories: less than 2,500 grams and 2,500 grams and over. Thus, in this research the neonatal mortality rate of light or low-weight infants pertains to infants weighing less than 2,500 grams at birth, and the neonatal mortality rate of normal-weight infants pertains to infants weighing 2,500 grams or more at birth. Preliminary research suggested that the basic results were not sensitive to an alternative definition of low birthweight of less than 2,000 grams. This research also suggested that little was gained when the light category was divided into very low weight (less than 1,500 grams) and moderately low weight (1,500-2,499 grams).[9]

Separate regressions are fitted for white and black birth outcomes because the black neonatal mortality rate (not birthweight-specific) is twice

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[8] A fuller description of both the dependent and independent variables is available from the authors upon request.

[9] The above findings may be due to the aggregate nature of the data set and the limited number of observations in it. The NIMS project represented the first step in the development of a national micro data base containing linked birth and death certificates, but it did not result in such a data base. Provided it identified county of residence, such a data set would be ideal for research on infant mortality.

as high as the white rate, and the black fraction of light births is twice as high as the white fraction. By fitting race-specific regressions, multicollinearity is reduced, and the coefficients of the explanatory variables are allowed to vary between races.

The white regressions are estimated for the fifty states and the District of Columbia or for 51 observations. Some states have a small number of blacks, and the black mortality rates in these states are unreliable because they are based on very few births. Therefore, we include only states with a population of at least 20,000 blacks in 1980 and with at least 600 black births in that year in the black regressions. There are 39 observations in these regressions.[10] To further attenuate the role of random elements in the determination of birth outcomes for both races, we estimate weighted regressions, where the set of weights is the square root of the race-specific number of live singleton births. The weights are birthweight-specific in the neonatal mortality weight equations but not in the low-birthweight equations.[11]

B. Measurement of Explanatory Variables

Table 1 contains means and standard deviations of the variables.

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[10] The following states are excluded from the black regressions: Alaska, Hawaii, Idaho, Maine, Montana, New Hampshire, New Mexico, North Dakota, South Dakota, Utah, Vermont, and Wyoming.

[11] The fraction of light births ranges between zero and one, and the birthweight-specific death rate, when divided by one thousand, also possesses this property. Maddala (1983) shows that the weighted estimation procedure described in the text is the appropriate one to employ in fitting linear probability functions with aggregate data. Thus, we do not sacrifice statistical appropriateness by the choice of a linear functional form.

We choose the linear form because it facilitates a decomposition of the total impact on neonatal mortality of a given determinant into effects operating through low birthweight and through birthweight-specific neonatal mortality (see note 7).

Wherever possible, race-specific variables are employed in the regressions. Such variables are denoted with an asterisk. The key input availability measures in the reduced form pertain to abortion, neonatal intensive care, and five public programs aimed at poor women. All of these measures are expected to have negative regression coefficients.

Abortion availability is given by the number of abortion providers in 1980 per thousand women aged 15 through 44 in that year.[12] Neonatal intensive care availability is measured by the sum of the number of hospitals with Level II, Level III, or Levels II and III neonatal intensive care units in 1979 per thousand women aged 15 through 44 in 1980.

The extent of the Special Supplemental Food Program for Women, Infants, and Children (WIC program) is given by the number of WIC projects in 1980 per thousand women aged 15 through 44 with family income less than 200 percent of the poverty level in 1980. The availability of maternal and infant care (MIC) projects is given by the fraction of counties served by such projects in 1980. This variable was obtained from a survey of MIC projects taken by Richard Frank, David Salkever, Donna Strobino, and Emily DeCoster of the Johns Hopkins University School of Public Health as part of an ongoing research project on the impacts of financing maternity care for the poor and uninsured.[13]

The availability of projects funded by the Bureau of Health Care Delivery and Assistance (BHCDA) is the number of projects funded by BHCDA and

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[12] The number of women aged 15 through 44 and their poverty and schooling levels (see below) come from the 1980 Census of Population (either the state volumes or the five percent A Sample).

[13] Donna Strobino, who has done a number of extremely important studies of the MIC program (Strobino 1982; Strobino et al. 1986), urged us to use this measure because enrollment in MIC is subject to significant restrictions.

designated community health centers or migrant health centers in 1982 per thousand women aged 15 through 44 with family income less than 200 percent of the povery level in 1980. Organized family planning clinic availability is given by the number of organized family planning clinics in 1980 per thousand poor women aged 15 through 44. Medicaid coverage of prenatal care for first-time pregnancies in 1980 is reflected by a dichotomous variable that equals one if a state covered at least some first-time pregnancies of financially eligible women in that year. It serves as a general proxy for the eligibility of pregnant low-income women for Medicaid coverage of prenatal care services and for the generosity of Medicaid benefits[14].

The fraction of women aged 15 through 44 who had at least a high school education in 1980 is a proxy for mother's efficiency in preventing undesired pregnancies, in producing healthy offspring, and other aspects of efficiency in household production. The schooling variable also may serve as a proxy for the parents' preferences for healthy offspring. In addition, the schooling variable is negatively related to poverty (the fraction of women aged 15 through 44 with family income less than 200 percent of the poverty level in 1980). The poverty measure could not be included in the regressions due to multicollinearity.[15] Whether schooling represents efficiency, tastes, absence of poverty, or all three factors, poor birth outcomes should be negatively related to it.

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[14] Attempts to introduce additional Medicaid variables were unsuccessful due to multicollinearity and the limited number of observations in our data.

[15] For the same reason we could not pursue a model in which the fraction of poor women is interacted with the public program measures.

The reduced form regressors discussed so far measure the same basic determinants as those used by Corman and Grossman (1985). The last two variables--the percentage of the population residing in urban areas in 1980 and population per square mile in 1980--were not previously used. They are used here because our data pertain to states rather than to large urban counties. The signs of the regression coefficients of these two variables are left as open issues. We note, however, that they may reflect such forces as overcrowded housing, transportation facilities, poverty, and air pollution. Both measures were taken from the 1980 Census of Population.

Residents of some states may receive medical care services in neighboring states in which these services are more available. This problem is particularly relevant to the District of Columbia (Washington, DC) and the bordering states of Maryland and Virginia. To deal with the above problem, abortion availability and neonatal intensive care availability in the District of Columbia and contiguous states were adjusted based on the distribution of women aged 15 through 44 in the DC SMSA.

IV. Empirical Results

Estimates of reduced form birth outcome equations are presented below. The reader is cautioned that by using states as the units of observation, we have a limited number of degrees of freedom. The small sample size also causes substantial multicollinearity. These phenomena make it difficult to uncover statistically significant relationships. Excessive emphasis on statistical significance at the expense of the signs and magnitudes of key effects can be misleading in a state data base.[16] In our discussion of the results, we stress the sign and magnitude of a particular effect rather than its significance. We are, however, cautious, about highlighting regression coefficients whose t-ratios are smaller than one in absolute value.

A related problem is that the state may not be the appropriate unit of observation for estimating the impacts on birth outcomes of some of the inputs stressed in this research. This is because there is substantial intercounty variation in the availability and use of these inputs within a given state. In the case of neonatal intensive care, the state may be the more relevant market area, since many states have regional referral networks for ill neonates.[17] Unfortunately, for the other inputs, state-level data may mask a considerable amount of intercounty variation.

Tables 2, 3, and 4 contain reduced form regressions for low birthweight, the neonatal mortality of low-weight infants, and the neonatal mortality rate of normal-weight infants, respectively. Panel A of each table pertains to whites, while Panel B pertains to blacks. Four regressions are shown in each panel. The first limits the set of explanatory variables to abortion providers and neonatal intensive care hospitals. The second adds the five public program availability measures to the set of regressors. The third regression includes the fraction of women aged 15 through 44 with at least a high school education, while the fourth adds population density and the percentage of the

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[16] Some investigators deal with this problem by viewing a data base such as ours as the universe rather than as a sample becauses it covers the entire population of the U.S. in a single year.

[17] For the above reason, we measured neonatal intensive care availability and use at the state level in previous research, even though the data on birth outcomes pertained to counties (Corman and Grossman 1985; Corman, Joyce, and Grossman 1987; Joyce 1987a, 1987b; Joyce, Corman, and Grossman 1988).

population residing in urban areas.

Four regressions are presented due to the problems of multicollinearity and a limited number of degrees of freedom. Our previous research serves as a guide to the order in which regressors are entered. Since we found abortion and neonatal intensive care to be the most important determinants of neonatal mortality, these measures are included first. We did not consider urbanization and population density in our work with county data; hence, these two variables are omitted until the final regression. Because schooling is highly correlated with a number of the availability variables, regressions are shown with and without this variable.

The most novel aspect of the results in Tables 2, 3, and 4 is the light that they shed on the role of neonatal intensive care availability in birth outcomes. A priori, we expect the availability of this input to be most important in the case of the neonatal mortality rate of low-weight infants. This expectation is realized in the case of whites. According to the four regressions in Panel A of Table 3, an increase in the availability of neonatal intensive care lowers the neonatal mortality rate of white low-weight infants. The regression coefficients of this variable are statistically significant at the 5 percent level on a one-tailed test except in regression (3W-2), where the coefficient is significant at the 10 percent level. On the other hand, when the fraction of low-weight births or the neonatal mortality rate of normal-weight infants is the dependent variable, the neonatal intensive care coefficients are positive in six of eight cases and have t-ratios smaller than one except in regression (4-W4).

Neonatal intensive care effects are less clearcut for blacks. The neonatal mortality rate of black low-weight infants falls as availability rises except in the last regression in Panel B of Table 3. Each negative regression coefficient, however, has a t-ratio smaller than one in absolute value. The availability effects for the neonatal mortality rate of black normal-weight infants mirror the corresponding white effects. But the fraction of black low-weight births is inversely related to neonatal intensive care availability, and the four regression coefficients in Panel B of Table 2 are significant at the 5 percent level. In the reduced form low-birthweight equation the coefficient of neonatal intensive care availability reflects substitution or complementary relationships between neonatal intensive care use and other inputs. Thus, one interpretation of the result just discussed is that neonatal intensive care use and inputs that determine birthweight are complements: a reduction in the price (an increase in the availability) of neonatal intensive care raises the use of these inputs. Another interpretation is that neonatal intensive care availability serves as a general proxy for the availability of medical care inputs that contribute to favorable birth outcomes in the case of blacks.

In addition to neonatal intensive care availability, the number of abortion providers reflects the availability of a general health input used by all segments of the population as opposed to a public program measure used only by the poor. For whites, the number of abortion providers has negative and significant coefficients in the mortality equation for low-weight births. Presumably, this finding reflects complementarity between abortion availability and neonatal intensive care use. In the normal-weight mortality regressions, a negative effect is observed when schooling is omitted from the set of explanatory variables but not when it is included.[18] Abortion availability has no impact on the incidence of low birthweight. For blacks, all twelve abortion provider coefficients are negative in Tables 2, 3, and 4. In general the birthweight and normal-weight mortality effects are more significant than the low-weight mortality effects, but even the latter have absolute t-ratios greater than one in three of four cases.

With regard to the public program measures, the availability of BHCDA projects can be dismissed as a determinant of the outcomes at issue in this research since its regression coefficient always is positive both for whites and blacks.[19] The coefficients of the four other program measures are negative in a majority of cases for each race. Specifically, for whites, six of the nine WIC and MIC effects are negative, five of the nine family planning effects are negative, and all nine Medicaid effects are negative. For blacks, the corresponding figures are six of nine in the cases of MIC, family planning, and Medicaid, and all nine in the case of WIC. There are far fewer statistically significant effects or effects with absolute t-ratios greater than one for the five public program measures than for the set consisting of the two general availability measures (neonatal intensive care and abortion).[20]

The final three variables in the reduced form are female schooling,

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[18] In general an increase in abortion availability lowers the cost of fertility control. This reduces the optimal number of births and raises the optimal survival probability by increasing the amount of rsources allocated to each birth (Corman and Grossman 1985).

[19] One interpretation of the above result is that BHCDA projects service all segments of the poverty population as opposed to women of childbearing age.

[20] In estimates not shown we regressed the health outcomes on the public program measures alone. These results did not change the above conclusion.

urbanization, and population density. In the full low-birthweight equation for each race [(3-W4) and (3-B4)], the schooling coefficient has the correct negative sign and is statistically significant. The schooling coefficients also are negative and significant in the white normal-weight mortality regressions. An increase in the percentage of the population residing in urban areas raises the race-specific fraction of light births but lowers the white low-weight mortality rate. Finally, more densely populated states have higher black low-weight mortality rates and higher white normal-weight mortality rates.

V. Discussion

To gauge the magnitudes of the estimated relationships, we computed the impact of a one standard deviation increase in a given determinant on birthweight-specific neonatal mortality rates and on the fraction of light births. These computations are made only for the two most important determinants: neonatal intensive care availability and abortion availability. They employ an average of the four regression coefficients of a given determinant obtained for each of the three health outcomes and are performed only if this average is negative.

For whites, a one standard deviation increase in neonatal intensive care availability lowers the mortality rate of low-weight infants by 3.4 deaths per thousand live births or by 4 percent relative to a mean of 89.9 deaths per thousand live births. This translates into a reduction in the overall white neonatal mortality rate (not birthweight-specific) of .2 deaths per thousand live births, which amounts to a reduction of 3 percent relative to a mean of

6.3 deaths per thousand live births.[21] For blacks, a one standard deviation increase in the neonatal intensive care measure lowers the mortality rate of low-weight infants by 1.2 deaths per thousand live births or by 1 percent based on a mean of 88.9 deaths per thousand live births. At the same time, the fraction of light births falls by .002, which equals 2 percent of the mean black fraction of light births of .113.[22] This implies a decline in the black overall neonatal mortality rate (mean = 12.6 deaths per thousand live births) of of .3 deaths per thousand live births or 3 percent.

For whites, a one standard deviation expansion in abortion availability reduces the mortality rate of low-weight infants by 3.2 deaths per thousand live births. Simultaneously, the mortality rate of white normal-weight infants, which has a mean of 2.0 deaths per thousand live births, falls by less than .1 deaths per thousand live births. The decline in the overall mortality rate of .2 deaths per thousand live births is the same as in the case of a one standard deviation increase in neonatal intensive care. For

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[21] Based on note 7, let x be a given determinant, b be the race-specific fraction of light births, d_i $(i = 1,2)$ be the race-and birthweight-specific mortality rate, and d be the overall race-specific mortality rate. Then

$$(\delta d/\delta x) = (d_1-d_2)(\delta b/\delta x) + b(\delta d_1/\delta x) + (1-b)(\delta d_2/\delta x).$$

For whites, neonatal intensive care availability has no impact on b or d_2. When a determinant alters two or more outcomes, $(\delta d/\delta x)$ is evaluated at the mean values of d_1, d_2, and b.

[22] If the incidence of low birthweight is expressed as a percent, the absolute decline is .2 percentage points based on a mean of 11.3 percent. Obviously, this also amounts to a 2 percent decline in the number of low-weight births.

blacks, the abortion availability effect amounts to a decline in the low-weight mortality rate of 3.0 deaths per thousand live births or of 3 percent, a decline in the normal-weight mortality rate (mean = 2.8 deaths per thousand live births) of .2 deaths per thousand live births or of 7 percent, and a decline in the overall mortality rate of .7 deaths per thousand live births or of 6 percent. This is more than twice as large as the decline associated with a one standard deviation increase in neonatal intensive care.

The coefficients of variation of the two general availability measures are substantial: 40 percent in the case of neonatal intensive care and 54 percent in the case of abortion. Therefore, our results suggest that neonatal mortality rates could be lowered by policies that reduce the inequality in these health resources across states. Our results also suggest that white low-weight infants benefit more from the availability of neonatal intensive care hospitals than black low-weight infants. This may be because blacks encounter substantial financial barriers in attempting to use these hospitals. The larger effect of abortion for blacks relative to whites is consistent with the wider use of abortion as opposed to conventional contraceptive methods by blacks than by whites (for example, Stephen, Rindfuss, and Bean 1988).

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Table 1

Means and Standard Deviations of Variablesa

Variables	Whites		Blacks	
	Mean	Std. Dev.	Mean	Std. Dev.
Neonatal mortality rate of low birth-weight infants*b	89.896	11.849	88.939	14.915
Neonatal mortality rate of normal-birthweight infants*c	1.968	.285	2.818	.537
Fraction of low-birthweight births*	.049	.005	.113	.007
Abortion providers	.051	.028	.047	.024
Neonatal intensive care hospitals	.010	.004	.010	.003
WIC projects	.090	.070	.082	.064
MIC projects	.051	.066	.059	.067
BHCDA projects	.036	.019	.037	.018
Family planning clinics	.298	.114	.319	.128
Medicaid	.583	.493	.503	.500
Fraction High School educated*	.735	.037	.605	.052
Percentage urban*	72.082	13.217	85.194	15.749
Population density	189.037	295.230	331.928	1156.294

* An asterisk next to a variable indicated that it is race-specific. White means and standard deviations are based on 51 observations. Black means and standard deviations are based on 39 observations. Unless otherwise indicated, means and standard deviations are weighted by the race-specific total number of live singleton births in 1980.

b Weighted by the race-specific total number of live low-birthweight singleton births in 1980.

c Weighted by the race-specific total number of live normal-birthweight singleton births in 1980.

Table 2

Low-Birthweight Reduced Form Regressions[a]

	Panel A: Whites			
Explanatory Variable	(2-W1)	(2-W2)	(2-W3)	(2-W4)
Constant	0.049 (18.27)	0.045 (14.66)	0.089 (5.39)	0.094 (5.64)
Abortion providers	0.013 (0.49)	0.007 (0.28)	0.037 (1.36)	0.031 (1.11)
Neonatal intensive care hospitals	-0.063 (-0.31)	-0.113 (-0.58)	0.023 (0.12)	0.153 (0.76)
WIC projects	---- ----	-0.010 (-0.94)	-0.008 (-0.81)	-0.002 (-0.18)
MIC projects	---- ----	0.010 (0.80)	0.016 (1.37)	0.014 (1.25)
BHCDA projects	---- ----	0.026 (0.63)	0.019 (0.47)	0.041 (0.97)
Family planning clinics	---- ----	0.018 (2.58)	0.009 (1.24)	0.010 (1.44)
Medicaid	---- ----	-0.002 (-1.08)	-0.0004 (-0.29)	-0.0004 (-0.24)
Fraction high school educated*	---- ----	---- ----	-0.062 (-2.73)	-0.084 (-3.26)
Percentage urban*	---- ----	---- ----	---- ----	0.0001 (1.41)
Population density	---- ----	---- ----	---- ----	0.000002 (0.93)
R^2	0.008	0.241	0.355	0.402
F	0.19	1.95	2.89	2.69

	Panel B: Blacks			
Explanatory Variable	(2-B1)	(2-B2)	(2-B3)	(2-B4)
Constant	0.125 (31.64)	0.129 (25.15)	0.134 (7.32)	0.137 (8.03)
Abortion providers	-0.124 (-3.08)	-0.125 (-2.69)	-0.117 (-2.20)	-0.068 (-1.29)
Neonatal intensive care hospitals	-0.634 (-2.12)	-0.748 (-1.81)	-0.751 (-1.79)	-0.748 (-1.89)
WIC projects	---- ----	-0.015 (-0.90)	-0.016 (-0.92)	-0.004 (-0.22)
MIC projects	---- ----	-0.014 (-0.76)	-0.016 (-0.80)	-0.036 (-1.77)
BHCDA projects	---- ----	0.026 (0.36)	0.018 (0.24)	0.105 (1.28)
Family planning clinics	---- ----	-0.003 (-0.24)	-0.003 (-0.28)	0.003 (0.30)
Medicaid	---- ----	-0.001 (-0.52)	-0.001 (-0.44)	-0.001 (-0.53)
Fraction high school educated*	---- ----	---- ----	-0.008 (-0.30)	-0.066 (-1.91)
Percentage urban*	---- ----	---- ----	---- ----	0.0003 (2.18)
Population density	---- ----	---- ----	---- ----	0.000001 (0.95)
R^2	0.246	0.291	0.293	0.439
F	5.88	1.82	1.55	2.19

[a] t-ratios in parentheses. An asterisk next to a variable means it is race specific. There are 51 observations in the white regressions and 39 observations in the black regressions. t ratios of about 1.31 and 1.68 reveal significance(one-tailed) at 10% and 5% levels respectively.

Table 3

Neonatal Mortality Rate Reduced Form Regressions, Low-Birthweight Births[a]

	Panel A: Whites			
Explanatory Variable	(3-W1)	(3-W2)	(3-W3)	(3-W4)
Constant	103.555	112.838	68.701	61.848
	(18.25)	(16.28)	(1.71)	(1.50)
Abortion providers	-113.291	-99.378	-129.993	-112.879
	(-2.00)	(-1.63)	(-1.95)	(-1.61)
Neonatal intensive care hospitals	-763.951	-717.581	-854.715	-1063.835
	(-1.77)	(-1.571)	(-1.81)	(-2.10)
WIC projects	----	-31.327	-32.993	-43.987
	----	(-1.31)	(-1.38)	(-1.72)
MIC projects	----	-11.085	-17.227	-16.343
	----	(-0.40)	(-0.62)	(-.58)
BHCDA projects	----	5.451	13.724	-36.689
	----	(0.06)	(0.14)	(-0.35)
Family planning clinics	----	-18.205	-9.604	-11.963
	----	(-1.15)	(-0.55)	(-0.67)
Medicaid	----	-3.037	-4.208	-4.286
	----	(-0.87)	(-1.15)	(-1.17)
Fraction high school educated*	----	----	61.893	101.626
	----	----	(1.11)	(1.58)
Percentage urban*	----	----	----	-0.239
	----	----	----	(-1.21)
Population density	----	----	----	-0.001
	----	----	----	(-0.25)
R^2	0.123	0.232	0.253	0.282
F	3.37	1.85	1.79	1.57

	Panel B: Blacks			
Explanatory Variable	(3-B1)	(3-B2)	(3-B3)	(3-B4)
Constant	94.236	98.650	51.242	69.868
	(9.24)	(8.09)	(1.18)	(1.78)
Abortion providers	-47.659	-121.281	-188.079	-139.358
	(-0.45)	(-1.07)	(-1.48)	(-1.14)
Neonatal intensive care hospitals	-312.316	-479.748	-450.225	85.785
	(-0.39)	(-0.47)	(-0.45)	(0.09)
WIC projects	----	-63.147	-58.415	-37.210
	----	(-1.60)	(-1.48)	(-1.00)
MIC projects	----	60.901	75.110	76.626
	----	(1.33)	(1.59)	(1.64)
BHCDA projects	----	83.981	148.809	66.019
	----	(0.49)	(0.83)	(0.34)
Family planning clinics	----	3.438	7.845	-11.686
	----	(0.14)	(0.31)	(-0.46)
Medicaid	----	-3.913	-5.085	-2.178
	----	(-0.70)	(-0.90)	(-0.42)
Fraction high school educated*	----	----	75.741	57.046
	----	----	(1.14)	(0.71)
Percentage urban*	----	----	----	-0.128
	----	----	----	(-0.42)
Population density	----	----	----	0.006
	----	----	----	(2.96)
R^2	0.009	0.184	0.218	0.407
F	0.15	1.00	1.05	1.92

[a] t-ratios in parentheses. An asterisk next to a variable means it is race specific. There are 51 observations in the white regressions and 39 observations in the black regressions. t ratios of about 1.31 and 1.68 reveal significance(one-tailed) at 10% and 5% levels respectively.

Table 4

Neonatal Mortality Rate Reduced Form Regressions, Normal-Birthweight Births[a]

Explanatory Variable	(4-W1)	(4-W2)	(4-W3)	(4-W4)
		Panel A: Whites		
Constant	2.005	1.990	4.568	4.777
	(14.56)	(11.56)	(4.92)	(5.02)
Abortion providers	-2.697	-1.878	-0.090	0.361
	(-1.96)	(-1.24)	(-0.06)	(0.22)
Neonatal intensive care hospitals	10.360	2.795	10.805	13.112
	(0.99)	(0.25)	(0.99)	(1.12)
WIC projects	----	0.004	0.097	0.133
	----	(0.01)	(0.18)	(0.23)
MIC projects	----	-1.112	-0.753	-0.865
	----	(-1.63)	(-1.16)	(-1.32)
BHCDA projects	----	2.843	2.360	2.009
	----	(1.18)	(1.05)	(0.82)
Family planning clinics	----	0.184	-0.319	-0.336
	----	(0.47)	(-0.79)	(-0.82)
Medicaid	----	-0.085	-0.016	-0.013
	----	(-0.98)	(-0.20)	(-0.15)
Fraction high school educated*	----	----	-3.615	-3.838
	----	----	(-2.82)	(-2.59)
Percentage urban*	----	----	----	-0.001
	----	----	----	(-0.33)
Population density	----	----	----	0.0002
	----	----	----	(1.34)
R^2	0.123	0.232	0.302	0.333
F	3.37	1.85	2.27	2.00

Explanatory Variable	(4-B1)	(4-B2)	(4-B3)	(4-B4)
		Panel B: Blacks		
Constant	3.026	2.778	3.654	3.584
	(8.80)	(6.55)	(2.39)	(2.24)
Abortion providers	-6.217	-7.056	-5.822	-5.697
	(-1.76)	(-1.80)	(-1.30)	(-1.16)
Neonatal intensive care hospitals	8.332	15.905	15.370	12.617
	(0.32)	(0.46)	(0.44)	(0.34)
WIC projects	----	-0.118	-0.206	-0.221
	----	(-0.09)	(-0.15)	(-0.15)
MIC projects	----	-0.204	-0.466	-0.624
	----	(-0.13)	(-0.28)	(-0.33)
BHCDA projects	----	8.497	7.299	8.395
	----	(1.42)	(1.15)	(1.08)
Family planning clinics	----	-0.612	-0.693	-0.546
	----	(-0.69)	(-0.77)	(-0.53)
Medicaid	----	0.221	0.242	0.226
	----	(1.14)	(1.22)	(1.08)
Fraction high school educated*	----	----	-1.400	-1.751
	----	----	(-0.60)	(-0.54)
Percentage urban*	----	----	----	0.003
	----	----	----	(0.23)
Population density	----	----	----	-0.00002
	----	----	----	(-0.30)
R^2	0.089	0.203	0.213	0.216
F	1.75	1.13	1.01	.77

[a] t-ratios in parentheses. An asterisk next to a variable means it is race specific. There are 51 observations in the white regressions and 39 observations in the black regressions. t ratios of about 1.31 and 1.68 reveal significance(one-tailed) at 10% and 5% levels respectively.