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DETERMINANTS OF NEONATAL MORTALITY RATES IN THE U.S.

A Reduced Form Model*

Hope CORMAN

Manhattan College, New York, NY 10471, USA
National Bureau of Economic Research, New York, NY 10003, USA

Michael GROSSMAN

City University of New York Graduate School, NY 10036, USA
National Bureau of Economic Research, New York, NY 10003, USA

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The aim of this paper is to contribute to an understanding of the determinants of differences in race-specific neonatal mortality rates among large counties of the U.S. in 1977. After estimating cross-sectional regressions, we apply their coefficients to national trends in the exogenous variables to 'explain' the rapid decline in neonatal mortality since 1964. The regressions and the extrapolations point to the importance of abortion availability, neonatal intensive care availability, females' schooling levels, Medicaid, and to a lesser extent Bureau of Community Health Services projects, poverty, maternal nutrition programs and organized family planning in trends in black neonatal mortality between 1964 and 1977. They also underscore the importance of schooling, neonatal intensive care, poverty, Medicaid, maternal nutrition programs, abortion, and organized family planning clinics in trends in white neonatal mortality in those years.

1. Introduction

During the period from 1955 through 1982, the behavior of the U.S. infant mortality rate has been characterized by a decade of relative stability

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followed by almost two decades of rapid decline. The rate declined by only 0.6 percent year compounded annually between 1955 and 1964. By contrast, infant mortality declined 4.5 percent per year (compounded annually) between 1964 and 1982.[1]

The trend in the infant mortality rate since 1964 has been dominated by the trend in the neonatal mortality rate (deaths of infants within the first 27 days of life) for two reasons. First, the neonatal mortality rate, 8.9 deaths per thousand live births in 1979, is twice as large as the postneonatal mortality rate (deaths of infants between the ages of 28 and 364 days per thousand live births), which equaled to 4.2 in 1979. Second, the neonatal mortality rate has fallen at a faster pace than the postneonatal mortality rate since 1964 (4.6 percent per year versus 3.9 percent per year). The result of these two factors is that the decline in the neonatal mortality rate accounted for 77 percent of the reduction in the infant mortality rate during the past two decades. It follows that any attempt to explain the recent behavior of infant mortality must focus on neonatal mortality.

The period beginning in 1964 witnessed the introduction of Medicaid, maternal and infant care (M and I) projects, community health centers (CHCs, formerly called neighborhood health centers), Federally subsidized family planning services for low-income women, the Special Supplemental Food Program for Women, Infants, and Children (WIC program), the legalization of abortion, the widespread adoption of oral and intrauterine contraceptive techniques, and dramatic advances in perinatal[2] and neonatal science. Although other researchers have related these developments to accelerations in the downward trends in infant and especially neonatal mortality rates [for example, Eisner et al. (1978), Kleinman et al. (1978), Lee et al. (1980), David and Siegal (1983)], there have been few attempts to study this issue in a multivariate context. Moreover, there has been only one previous effort to quantify the relative contributions of at least some of these factors [Grossman and Jacobowitz (1981)]. Therefore, the aim of this paper is to contribute to an understanding of the determinants of neonatal mortality rates in the U.S. with an emphasis on the factors just mentioned. Estimates of their effects control for such basic correlates of neonatal mortality as poverty, schooling levels, and the availability of obstetricians/gynecologists.

The aim is implemented by conducting cross-sectional regression analyses of differences in race-specific neonatal mortality rates among counties of the U.S. in 1977. This procedure capitalizes on variations in the public program

[1]The above computations are based on data contained in National Center for Health Statistics (1983).

[2]The perinatal period is the period around the time of birth, generally defined as from twenty weeks of gestation up to seven days of life.

at issue and in units that deliver sophisticated perinatal and neonatal care services among counties at a moment in time. After estimating the regressions, we apply their coefficients to national trends in the exogenous variables to 'explain' the downward trend in neonatal mortality.

2. Analytical framework

Economic models of the family developed by Becker and Lewis (1973) and Willis (1973) provide a fruitful theoretical framework to generate multivariate health outcome functions and to assess the roles of a variety of factors in these functions. Ben-Porath and Welch (1976), Williams (1976), Grossman and Jacobowitz (1981), Rosenzweig and Schultz (1982, 1983a, b) and Lewit (1983) have utilized the economic model of the family to study theoretically and empirically the determinants of birth outcomes. Following these authors, we assume that the parents' utility function depends on their own consumption, the number of births, and the survival probability. Both the number of births and the survival probability are endogenous variables. In particular, the survival probability production function depends upon such endogenous inputs as the quantity and quality of medical care, nutrition, and the own time of the mother. In addition, the production function is affected by the mother's efficiency in producing healthy offspring and by other aspects of her efficiency in household production. Given the considerable body of evidence that education raises market and non-market productivity, one would expect more educated mothers to be more efficient producers of surviving infants.

Maximization of the parents' utility function subject to production and resource constraints generates a demand function for survival in which the survival probability is related to input prices, efficiency, income, tastes, and the fixed costs of a birth. Fixed costs are costs that are independent of the survival probability. For example, Willis (1973) shows that birth control costs are negatively correlated with the fixed costs of a birth. A reduction in the cost of fertility control raises the fixed cost of a birth, reduces the optimal number of births, and raises the optimal survival probability. The interaction between the survival demand and production functions determines demand functions for medical care and other endogenous inputs. These derived demand functions depend on the same set of variables as the demand function for the probability of survival.

The above model calls attention to the important determinants of the survival probability and its complement, the neonatal mortality rate. In general this set of determinants is similar to that used in multivariate studies of neonatal mortality with different points of departure [for example, Fuchs (1974), Williams (1974), Brooks (1978), Gortmaker (1979), Hadley (1982), Harris (1982)]. Moreover, the model provides a ready structure within which to interpret the impacts of the factors at issue in our research.[3] Thus, for example, Medicaid, M and I projects, and community health centers lower the direct and indirect costs[4] of obtaining medical care, which should increase the likelihood of a favorable birth outcome and lower neonatal mortality. Similar comments apply to the impacts of increases in the availability of physicians who deliver prenatal and perinatal care services and to the number of hospitals with perinatal and neonatal intensive care units, which provide constant and continuous care to critically ill newborn infants. An expansion in the percentage of eligible pregnant women served by the WIC program raises the availability of appropriate nutrition, an important non-medical input in the production of healthy infants. Subsidization of family planning services and the diffusion and availability of abortion services reduce the cost of fertility control. Within the context of an economic model of the family, these developments raise the 'optimal' survival probability and lower the 'optimal' number of births. In addition, they will lower the observed infant mortality rate if less healthy fetuses are less likely to be conceived or more likely to be aborted.

The preceding ideas are formalized in the following six equation model:

$$1-d=f_1(n,b), \quad b=f_2(m,a,c,z), \qquad (1), (2)$$

[3]Brief descriptive and historical information concerning these factors is as follows. Medicaid, enacted in 1965 as Title XIX of the Social Security Act of 1935, is the joint Federal–state program to finance the medical care services of low-income families who are covered by the aid to families with dependent children (AFDC) program. Maternal and infant care projects originated in the 1963 amendment to Title V of the Social Security Act. The amendment provides special Federal grants for projects designed to provide adequate prenatal and obstetrical care to reduce the incidence of mental retardation and other conditions caused by childbearing complications as well as to lower infant and maternal mortality. The program to create and fund community health centers was started by the Office of Economic Opportunity as part of the War on Poverty in 1965. By 1973 overall control of the centers had been shifted to the Bureau of Health Care Delivery and Assistance (formely called the Bureau of Community Health Services), DHHS. CHCs deliver comprehensive ambulatory care, both primary and preventive, to poverty populations in medically underserved areas. The Special Supplemental Food Program for Women, Infants, and Children (WIC program) was authorized by a 1972 amendment to the Child Nutrition Act of 1966. Under the program the Federal government gives cash grants to state health departments and local health clinics to provide special nutritious food supplements to low-income pregnant and lactating women, infants, and children up to four years of age who are nutritional risks. Federal subsidization of family planning services for low-income women originated in the 1967 amendments to the Social Security Act. Federal efforts in this area were expanded by the Family Planning Services and Population Research Act of 1970 and by the 1972 amendments to the Social Security Act. These subsidies go to family planning clinics organized by hospitals, state and local health departments, Planned Parenthood, and other agencies. Prior to 1967 all states of the United States had laws which permitted abortion only when it was necessary to preserve a pregnant woman's life. By the middle of 1970, sixteen states had reformed their laws to increase the number of circumstance under which abortions could be performed. In 1973 the Supreme Court ruled most restrictive state laws unconstitutional. Information on neonatal intensive care units is provided below.

[4]The indirect costs of obtaining a good are generated by the time spent traveling, waiting, and obtaining information about the good. We use the terms cost and availability as synonyms. In particular, with other factors held constant, an increase in availability is associated with reductions in direct and indirect costs.

$$n=f_3(p,z,y), \quad m=f_4(p,z,y), \tag{3), (4}$$

$$a=f_5(p,z,y), \quad c=f_6(p,z,y). \tag{5), (6}$$

Eqs. (1) and (2) are production functions, while eqs. (3)–(6) are input demand functions. In eq. (1) the probability that an infant survives the first month of life ($1-d$, where d is the probability of death) is shown as a function of a vector of perinatal and neonatal care inputs (n) and birth weight (b).[5] Note that there is an overwhelming amount of evidence that low birth weight (less than or equal to 2,500 grams or 5.5 pounds) is the most important and most proximate endogenous risk factor in neonatal health outcomes [for example, Harris (1982), Lewit (1983)]. In eq. (2) birth weight is a function of a vector of prenatal medical and non-medical inputs (m),[6] the use of abortion services (a), the use of contraceptive services (c), and exogenous risk and productive efficiency factors such as mother's education (z). In eqs. (3)–(6), the inputs are related to a vector of price and availability measures (p), socioeconomic characteristics which reflect command over resources and tastes (y), and productive efficiency and risk factors (z).

The two production functions are structural equations because they show relationships among endogenous variables. Substitution of the input demand functions into the production functions yields

$$1-d=f_7(p,z,y), \tag{7}$$

$$b=f_8(p,z,y). \tag{8}$$

These are reduced form equations because only exogenous variables appear on their right-hand sides. They may be termed demand functions for survival and birth weight. Together with the input demand functions, they constitute the reduced form of the model.[7] Although eqs. (1)–(8) have meaningful interpretations at the family level, our empirical analysis focuses on county-level data for the year 1977. Therefore, from now on we interpret d as the observed neonatal mortality rate and b as the percentage of low-birth weight births.

[5]The variable b can be interpreted as the probability of a low-birth weight birth.

[6]Some of the non-medical inputs, such as maternal cigarette smoking and alcohol use, have negative marginal products in the birth weight production function.

[7]The input demand functions are reduced form equations because they are obtained by maximizing a utility function subject to production and resource constraints. Note that the above specification contains the restriction that prenatal care and the exogenous risk factors affect survival only through their impacts on birth weight, but this restriction does not affect the nature of the reduced form. Note also that such endogenous risk factors as mother's age at birth, parity, gestational age, and legitimacy status of the birth can be incorporated into the birth weight production function. This would add equations for each of these factors to the reduced form but would not alter the reduced form survival equation (7). As explained below, we focus on the estimation of eq. (7) in this paper.

We focus on the estimation of the reduced form neonatal mortality rate eq. (7) because its coefficients are well suited for understanding the impacts of changes in policy variables and for extrapolating cross-sectional regression results to national trends in exogenous variables to 'explain' the decline in neonatal mortality. Since the reduced form mortality function contains only exogenous variables, it can be fitted by ordinary least squares.[8]

Our model calls attention to the difference between the availability and the use of services such as family planning, abortion, prenatal care, perinatal care, and neonatal care, all of which determine birth outcomes. An increase in the availability of an input lowers its price and causes the quantity demanded of that input to rise but has an ambiguous effect on the demand for some other input. For example, an increase in the availability of abortion services may reduce the use of family planning services if these methods of fertility control are substitutes. Thus, an increase in the availability of one service can affect neonatal mortality both directly and indirectly, through its effect on the use of other services. By focusing on availability rather than use, we can capture both direct and indirect effects of changes in the availability of medical services on neonatal mortality.

3. Empirical specification

3.1. Data and measurement of neonatal mortality

The basic data set used here is the Area Resource File (ARF), a county-based data service, prepared by Applied Management Sciences, Inc., for the Bureau of Health Professions, U.S. Department of Health and Human Services. It incorporates information from different sources for the 3,077 counties of the United States. Neonatal deaths (by county of residence) by race for the years 1969 through 1978 are obtained from the National Center for Health Statistics (NCHS) Mortality Tape. Births (by county of residence) by race for those years are obtained from the NCHS Natality Tape. Health manpower data come from the American Medical Association. Data on socio-economic characteristics are taken from the 'Census of Population'. We have added measures pertaining to the policies and programs discussed previously from sources indicated in the appendix to this paper (available upon request).

For reasons mentioned in the introductory section, the empirical analysis focuses on the neonatal mortality rate as opposed to the postneonatal mortality rate or the total infant death rate. Also, this strategy is adopted because most neonatal deaths are caused by congenital anomalies, prematurity, and complications of delivery. These conditions are more sensitive to improved prenatal, perinatal and neonatal care than are the infectious

[8]Potential endogeneity problems are explored in more detail in section 3.

diseases and accidents that contribute to postneonatal mortality. Neonatal mortality may be particularly sensitive to abortion and organized family planning access for several reasons. First, women who are known to be at risk for conditions related to neonatal deaths will find it easier to prevent pregnancy. Second, for the women at risk who unexpectedly become pregnant, access to abortion services will be easier. Finally, when risks are discovered during a pregnancy, some women may choose abortion if services are accessible.

Separate regressions are fitted for white neonatal mortality and for black neonatal mortality. Black neonatal mortality rates are much higher than white rates. For example, in 1977 the black rate was almost twice as large as the white rate. In a non-race-specific regression, one would enter the percentage of black births to control for race differences. But this variable would be highly correlated with the percentage of low-income women, schooling, and other independent variables. By fitting race-specific regressions, multicollinearity is reduced and the coefficients of the independent variables are allowed to vary between races. In preliminary regressions we tested and rejected the hypothesis that slope coefficients but not intercepts are the same for whites and blacks. Linear regressions are estimated for reasons indicated in section 3.2.

Counties are our unit of observation since they are the smallest geographic units for which aggregate national data are available. We exclude small counties from the analysis, however, for several reasons. First, some counties are so small that people may receive medical care outside the county. Second, some very small counties experience few to no neonatal deaths simply because the number of births is so small. Since our statistical techniques require mortality rates to be greater than zero and less than one, exclusion of some counties is required. Also, smaller counties have missing or unreliable data for some of the independent variables. For these reasons, we include only counties with a population of at least 50,000 in 1970. A county also has at least 5,000 blacks for inclusion in the black regressions. There are 677 counties in the white regressions and 357 counties in the black regressions.[9] The counties used in the white regressions accounted for approximately 80 percent of the white population of the U.S. in 1970, and the counties used in the black regressions accounted for a similar percentage of the black population of the U.S. in that year. In addition to selecting large

[9]One county with a population of at least 50,000 persons in 1970 was eliminated from the sample because it was the only such county characterized as an isolated rural county with no incorporated place with a population of at least 2,500 persons in 1970. In addition, Washington, DC was excluded because of difficulty in defining its relevant market area for neonatal intensive care (NICU) availability. For all other counties, we defined the state as the relevant NICU area. Since this was impossible for DC, we eliminated the observation. Note that although 84 percent of all births in Washington, DC were black, DC black births accounted for less than 2 percent of all black births in the sample of 358 black counties.

counties, we attenuate random elements by employing a three-year average of the race-specific neonatal mortality rate for the period 1976–1978 as the dependent variable and by estimating weighted regressions, where the set of weights is the square root of the race-specific total number of births in the period 1976–1978.

Neonatal mortality for a three-year period centered on 1977 is studied to address the question: Do the effects that Grossman and Jacobowitz (1981) observed in 1971, particularly the large negative abortion effect, differ when data for 1977 are examined? Our approach also differs from theirs because we focus on a reduced form neonatal mortality rate equation, and we include many more determinants of neonatal mortality. For example, we are now able to measure the contribution of the rapid advances in perinatal and neonatal science since 1965.[10] These developments were accompanied by an approximately fourteen-fold increase in the number of hospitals with neonatal (defined to include perinatal) intensive care units between 1964 and 1977 [Sheridan (1983)]. Note that although the state-of-the-art in neonatology is fixed in the cross section, the availability of these state-of-the-art services varies considerably from one geographic area to another due to regional differences in hospital construction subsidies (by states and the Federal government), Medicaid reimbursement, Federal funding of neonatal intensive care centers (under Title V of the Social Security Act), state certificate-of-need laws and regionalization of neonatal intensive care programs.

3.2. Measurement of independent variables

Wherever possible, race-specific variables are employed in the regressions. Such variables are denoted with '[a]'. Except for the Medicaid, WIC, and neonatal intensive care measures, all variables are county-specific. Table 1 contains definitions of the dependent and independent variables in the regressions, and table 2 contains their means and standard deviations. Most of the independent variables pertain to one or more years in the 1975–1978 period. Several measures pertain to 1970, 1979, 1980 or 1981. In these cases the assumption is made that the 1975–1978 measure is highly correlated with the one actually used. A detailed description of the variables and their sources appears in the appendix (available upon request), which also contains a discussion of preliminary regression results obtained with several additional independent variables that are not shown in section 4.

The percentage of women aged 15 to 44 with family income less than 200 percent of the poverty level in 1980 (percent poor) is a negative correlate of

[10]These advances are described by the American Academy of Pediatrics (1977), the Committee on Perinatal Health (1977), and Budetti et al. (1981).

Table 1
Definitions of variables.

Variable name	Definition
Neonatal death rate (1977)[a]	three-year average neonatal mortality rate centered on 1977; deaths of infants less than 28 days old per 1,000 live births
Percent poor[a,b]	percentage of women aged 15–44 with family income less than 200 percent of the poverty level in 1980
Percent high school educated[a,c]	percentage of women aged 15–49 who had at least a high school education in 1970
Medicaid eligibility-1[d]	dichotomous variable that equals one if county is in state that covered all first-time pregnancies under Medicaid to financially eligible women in the period 1976–1978
Medicaid eligibility-2[d]	dichotomous variable that equals one if county is in state that covered first-time pregnancies under Medicaid only if no husband was present or if the husband was present but unemployed and not receiving unemployment compensation in the period 1976–1978
Medicaid eligibility-3[d]	dichotomous variable that equals one if county is in state that covered first-time pregnancies under Medicaid only if no husband was present in the period 1976–1978
Medicaid payment for newborn	dichotomous variable that equals one if county is in state in which Medicaid paid for newborn care under the mother's Medicaid number or did not pay for care under the mother's number but allowed pregnant women to register their 'unborn children' with Medicaid in 1981
Per capita Medicaid payment	state-specific average annual Medicaid payment per adult recipient in AFDC families in fiscal 1976
Family planning[e] clinics/1000	number of organized family planning clinics in 1975 per 1,000 women aged 15–44 with family income less than 200 percent of the poverty level in 1975
Community health projects[e]/1000 (BCHS projects)	sum of maternal and infant care (M and I) projects and community health centers (CHCs) in 1976 per 1,000 women aged 15–44 with family income less than 200 percent of the poverty level in 1975; numerator termed Bureau of Community Health Services (BCHS) projects
Maternal nutrition program (WIC)	state-specific percentage of eligible pregnant women served by the Special Supplemental Food Program for Women, Infants, and Children (WIC program) in 1980
Abortion providers/1000	three-year average number of abortion providers (public hospitals, private hospitals, non-hospital clinics and office based physicians) centered on 1976 per 1,000 women aged 15–44 in 1975)
Newborn intensive care hospitals/1000	sum of state-specific number of hospitals with level II, or level III, or levels II and III neonatal intensive care units in 1979 per 1,000 women aged 15–44 in state in 1975
Neonatal death rate (1970)[a]	three-year average neonatal mortality rate centered on 1970

[a]Variable is race-specific.

[b]Variable is available for non-blacks and blacks as opposed to whites and blacks.

[c]Variable is available for whites and non-whites as opposed to whites and blacks.

[d]Medicaid eligibility variables characterize the eligibility of first-time pregnant women for prenatal care under Medicaid. The omitted category pertains to states that cover non-first-time pregnancies because their AFDC programs do not recognize 'unborn children'.

[e]Since numerator of this variable is not race-specific, denominator also is not race-specific. Denominator is obtained by applying the race-specific percentage of women aged 15–44 with family income less than 200 percent of the poverty level in 1980 to the race-specific number of all women aged 15–44 in 1975.

Table 2
Means and standard deviations of dependent and independent variables.[a]

Variable	Raw variable: Mean (1)	Raw variable: Standard deviation (2)	Variables interacted with poverty[b]: Mean (3)	Variables interacted with poverty[b]: Standard deviation (4)
Whites				
Neonatal death rate (1977)[c]	8.837	1.596		
Percent poor[c]	26.617	8.779		
Percent high school educated[c]	62.830	7.306		
Medicaid eligibility-1	0.388	0.488	0.109	0.147
Medicaid eligibility-2	0.137	0.344	0.034	0.090
Medicaid eligibility-3	0.087	0.282	0.024	0.080
Medicaid payments for newborn	0.927	0.260	0.248	0.110
Per capita Medicaid payment	453.266	142.016	119.831	56.550
Family planning clinics/1000	0.271	0.190	0.071	0.057
Community health projects/1000	0.018	0.035	0.005	0.011
Maternal nutrition program (WIC)	26.289	7.804	7.084	3.314
Abortion providers/1000	0.056	0.043		
Newborn intensive care hospitals/1000	0.011	0.004		
Neonatal death rate (1970)[c]	13.336	1.940		
Blacks				
Neonatal death rate (1977)[c]	16.387	3.303		
Percent poor[c]	54.896	9.371		
Percent high school educated[c]	44.120	8.968		
Medicaid eligibility-1	0.265	0.442	0.139	0.235
Medicaid eligbility-2	0.106	0.309	0.054	0.159
Medicaid eligibility-3	0.166	0.373	0.102	0.230
Medicaid payments for newborn	0.943	0.232	0.520	1.57
Per capita Medicaid payment	448.560	137.223	241.201	70.450
Family planning clinics/1000	0.271	0.209	0.149	0.128
Community health projects/1000	0.025	0.032	0.014	0.019
Maternal nutrition program (WIC)	26.793	7.419	14.782	5.133
Abortion providers/1000	0.056	0.036		
Newborn intensive care hospitals/1000	0.010	0.003		
Neonatal death rate (1970)[c]	22.496	4.018		

[a]The white data pertain to 677 counties; the black data pertain to 357 counties. Means and standard deviations are weighted by the race-specific total number of births in the period 1976–1978.

[b]Where applicable, variables are multiplied by (percent poor)/100.

[c]Variable is race-specific.

command over resources and is expected to have a positive regression coefficient. As explained in section 2, the percentage of women aged 15 to 49 who had at least a high school education in 1970 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. Whether schooling represents efficiency, tastes, or both, the neonatal mortality rate should be negatively related to it.[11]

The key public program measures at issue in this paper pertain to Medicaid, organized family planning clinics, maternal and infant care projects, community health centers, maternal nutrition programs (WIC), abortion availability, and neonatal care availability. All of the measures are expected to have negative regression coefficients. The eligibility of low-income women who are pregnant for the first time for Medicaid coverage of their prenatal care services is reflected by three dichotomous variables. The likelihood that the newborn care received by the infant of a low-income woman will be financed by Medicaid is indicated by a dichotomous variable that equals one if a county is in a state in which Medicaid paid for newborn care under the mother's Medicaid number or did not pay for care under the mother's number but allowed pregnant women to register their unborn children with Medicaid in 1981.

There are no data on differences in the availability of Medicaid coverage of prenatal care for second- and higher-order births or on differences in the general availability of physicians to Medicaid-eligible women among states or counties. Therefore, the state-specific average annual Medicaid payment per adult recipient in AFDC families in fiscal 1976 is included as a regressor. Although this variable partly reflects the use of care, it also reflects price and availability. This is because physicians in states with relatively low reimbursement schedules under Medicaid are less likely to treat Medicaid patients [Sloan, Mitchell and Cromwell (1978)].

Organized family planning's availability is given by the number of organized family planning clinics in 1975 per thousand women aged 15 to 44 with family income less than 200 percent of the poverty level in 1975. The denominator pertains to poor women because the clinics primarily service poor women and because the relevant public program is aimed at the poor.

Dryfoos (1976) reports that almost all clients of family planning clinics use oral or intrauterine contraceptive techniques (the pill or the IUD). Consequently, the family planning variable indicates the price and availability of these techniques to low-income women. There are no direct measures of the availability of family planning services delivered by private physicians to poor or non-poor women. Also, there is no information concerning differences in contraceptive knowledge among counties. It is likely, however,

[11]In the context of the household production function model of consumer behavior, the sign of the efficiency effect in a particular output demand function is ambigous if, for example, an increase in the mother's schooling raises her productivity in the production of healthy infants by a smaller percentage than her productivity in other household activities [Grossman (1972), Michael (1972)]. Nevertheless, we think that it is reasonable to expect a negative schooling coefficient in the neonatal mortality rate regression.

that more educated women will have better birth control information. Thus, the schooling variable may partly reflect this factor.

The extent of the maternal and infant care program and the community health center program (BCHS projects) is given by the sum of the number of these projects in the county in 1976 per thousand women aged 15 to 44 with family income less than 200 percent of the poverty level in 1975. The number of poor women serves as the denominator of this variable for the same reason that it serves as the denominator of the family planning measure. The two project types are aggregated in the numerator because both provide prenatal care services to low-income women.[12] BCHS refers to the Bureau of Community Health Services (renamed the Bureau of Health Care Delivery and Assistance in 1982), which is the agency within the U.S. Department of Health and Human Services that has overall administrative responsibility for both maternal and infant care projects and community health centers.

The count of community health centers (CHCs) is limited to centers that were delivering services as of 1976 because the number of CHCs expanded rapidly between 1976 and 1978. Given Goldman and Grossman's (1982) evidence the CHCs affect infant mortality with a lag, the potential impacts of the new centers are not likely to be observed in our data. Note that the number of maternal and infant care projects was very stable between 1971 and 1978 [Grossman and Jacobowitz (1981)].

The availability of nutritional supplements to low-income women under the maternal nutrition program (WIC) is given by the state-specific percentage of eligible pregnant women served by WIC in 1980. Abortion availability is lagged because Grossman and Jacobowitz's (1981) estimates suggest that abortions performed in the first half of a given year affect the neonatality mortality rate during the second half of the year.

For part of our sample period (August 1977 through December 1978), Federal funding of abortions under Medicaid was banned by the Hyde Amendment except in cases where the woman's life was in danger. During that period, 28 states refused to pay for 'medically necessary' abortions. The other 22 states continued to finance most abortions for Medicaid-eligible women. We do not take account of this curtailment in the availability of abortion to low-income women in our regression analysis because it could have affected the neonatal mortality rate in 1978 alone. More importantly, Cates (1981) reports that an estimated 94 percent of pregnant low-income women 'at risk' obtained a legal abortion between August 1977 and February 1980, 65 percent with state funds and 29 percent with other sources of funding.[13] This suggests that abortion use by low-income women is very

[12]A more detailed justification for the aggregation of maternal and infant care projects and community health centers is contained in the appendix, which is available on request.

[13]Federal funding of abortions resumed temporarily in February 1980, pending a review by the U.S. Supreme Court of a ruling by Federal District Judge John F. Dooling, Jr. that declared

unresponsive to the money price of an abortion. It does *not* imply that abortion use is insensitive to such indirect costs as the time and money spent traveling to an abortion facility, the time spent waiting at the facility, and the time spent in obtaining information about alternative facilities. These indirect costs are likely to be very sensitive to the abortion availability measure used in the regression.

Neonatal intensive care availability is measured by the sum of the state-specific number of hospitals with level II, level III, or levels II and III neonatal intensive care units in 1979 per thousand women aged 15 to 44 in the state in 1975. Hospitals that provide neonatal intensive care are generally divided into three levels based on the intensity of care each is equipped to deliver. Level I hospitals provide minimal or normal newborn care, level II hospitals provide intermediate care, and level III hospitals provide the most intensive care [Budetti et al. (1981)]. Specific definitions of these three levels of neonatal care are contained in the recommendations of the Committee on Perinatal Health (1977), which were developed as guidelines for the regional development of perinatal health services.

In the estimation of the availability of neonatal intensive care, the state is used as the relevant market area rather than the county. This is because many states have developed formal or informal regional referral networks for ill neonates. Under regionalization, it is possible for a newborn to be transferred out of his county of birth, suggesting that the market area for this care is larger than the county. This is in contrast to organized family planning, BCHS project, and abortion availability where regional networks do not exist. Moreover, the decision to obtain neonatal intensive care is made jointly by the physician and the mother, whereas the mother or the potential mother plays a much more important role in the decision to obtain the other services at issue. To the extent that the appropriate market area is larger than the county but smaller than the state, and to the degree mothers cross state boundaries, the neonatal intensive care variable contains measurement error. If the error is not correlated with the true value of the variable, the estimate of the availability effect is biased toward zero.

Level I hospitals are excluded from the count of neonatal intensive care hospitals since they do not provide the specialized state-of-the-art services in neonatology, referred to earlier. The count does not distinguish between level II and level III hospitals because of definitional problems in the available data.

The final variable in the regressions is a three-year average of race-specific neonatal mortality rate centered on 1970. This variable is included to control for potential reverse causality relationships that may bias the coefficients of

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the Hyde Admendment unconstitutional. In June 1980 the Supreme Court reversed Judge Dooling's decision and upheld the constitutionality of the Hyde Amendment.

the program measures. The reverse causality exists because some of the public programs were specifically targeted at regions with poor health indicators. For example, sites for community health centers, maternal and infant care projects and family planning centers were selected on the basis of medical need as perceived by health planners.[14] For these programs, the availability of the program is positively related to the pre-program neonatal mortality rate. If the current and lagged mortality rates are positively related, then estimates of the impacts of these programs will be biased toward zero unless the initial level of mortality is included in the regression (assuming there is an effect). For other public programs, availability is negatively related to the pre-program neonatal mortality rate, causing the program coefficient to be overstated unless the lagged rate is included. For example, states that reformed their abortion laws by 1970 and enacted generous Medicaid programs tended to be liberal states with relatively large welfare programs and probably lower than average infant mortality rates. Thus, the dependence of program levels on the lagged mortality rate will cause a downward bias in the absolute value of a given program coefficient when the sign of the reverse causality relationship is positive and an upward bias in the absolute value of the coefficient when the sign of the reverse causality relationship is negative.

Including the lagged mortality rate may cause different biases in the coefficients. This is because of potential correlation between the lagged mortality rate and the error term. One possible source of this correlation would be a county-specific health endowment not fully measured by our independent variables. In the equation predicting the 1977 mortality rate, the unobserved health endowment would be included in the error term. Since some endowment affects the 1970 mortality rate the undesired correlation would result. We call this the 'serial correlation bias'. Ideally, an instrumental variable procedure could eliminate the source of bias. This would require a data set containing relevant instruments for the county mortality rates in 1970. Unfortunately, such a data set is not available. Instead, we include the lagged mortality rate and predict the direction of the biases.

The directions of the biases depends on relationships between key variables.[15] First, because of the positive covariance between the lagged

[14]See footnote 3 for detailed information.

[15]The direction of the bias on the lagged mortality rate coefficient depends on the sign of the correlation between this variable and the error term. We define our regression as

$$Y=a+bX+cZ+u,$$

where Y is the 1977 neonatal mortality rate, b is a vector of coefficients on all independent variables except the lagged mortality rate, X is a vector of all independent variables except the lagged mortality rate, Z is the lagged mortality rate, c is the coefficient on Z and u is an error term. Assuming that none of the X variables is correlated with u, the expected value of c is

$$\mathrm{E}(c)=c+(\sigma_c^2/\sigma_u^2)\mathrm{E}[\mathrm{cov}(Zu)].$$

Since σ_c^2 and σ_u^2 are positive, the direction of the bias depends on the sign of $\mathrm{E}[\mathrm{cov}(Zu)]$. If this mortality rate and the error term, we expect the coefficient on the lagged mortality rate to be overstated. The direction of the biases on the coefficients on the other variables depends on the partial correlation between that variable and the lagged mortality rate. For variables where the partial correlation is negative, program effects are biased toward zero and where the partial correlation is positive, program effects are overestimated due to serial correlation bias. Most of the programs were found to have a negative partial correlation with the lagged mortality rate,[16] implying a downward bias due to serial correlation. In fact the only program with a positive partial correlation with the lagged mortality rate for blacks and whites (and therefore expected overestimation due to serial correlation) is abortion services. In this case the relevant partial correlation coefficients are extremely small (0.01 for whites and 0.04 for blacks), suggesting that the bias is minimal. Due to the existence of both reverse causality bias and serial correlation bias, regressions are presented with and without the lagged mortality rate in section 4.[17]

A number of programs that we study are aimed at the poor. It follows that the impacts on neonatal mortality of such programs are larger the larger is the fraction of poor women. To be specific, let d_{pj} be the neonatal mortality rate of babies born to poor mothers in the jth county, and let d_{nj} be the neonatal mortality rate of babies born to non-poor mothers. As an identity,

$$d_j = k_j d_{pj} + (1 - k_j) d_{nj}, \tag{9}$$

where d_j is the observed neonatal mortality rate and k_j is the fraction of births to poor mothers. Specify behavior equations for d_{pj}, d_{nj} and k_j as follows:

$$d_{pj} = \alpha_0 + \alpha_1 x_{pj}, \tag{10}$$

is positive, the estimated c will be biased upward and conversely. For the coefficients on the X variables,

$$E(b) = b - (\sigma_b \sigma_c / \sigma_u^2) r_{xz} E[\text{cov}(Zu)],$$

where r_{xz} is the partial correlation between the X variables and Z. Since σ_b, σ_c, σ_u^2 and, in our case, $E[\text{cov}(Zu)]$ are all positive, the direction of the bias depends on the sign of r_{xz}. If r_{xz} is positive, the coefficient will be biased downward (more negative) and conversely. [See Grossman (1972, pp. 98–101) and Haitovsky (1968) for derivations of the above formulae.]

[16]The majority of independent variables have negative partial correlations with the lagged mortality rate. Exceptions are: poverty and abortion availability for both samples, BHCS programs for whites, Medicaid eligibility-2 for whites and Medicaid eligibility-1 and per capita Medicaid payments for blacks. The negative partial correlations imply reduced coefficients (in absolute value) when the lagged mortality rate is included.

[17]Since the partial correlations between the X variables and the lagged mortality rates are usually negative, then for most variables, the serial correlation bias causes a downward estimate (in absolute value) of the coefficient. Therefore, when the sign of the reverse causality bias is negative, inclusion of the lagged mortality rate will cause lower bound estimates of program effects and exclusion will cause upper bound estimates.

$$d_{nj}=\beta_0, \tag{11}$$

$$k_j=\gamma_0+\gamma_1 y_j+\gamma_2 x_{pj}. \tag{12}$$

In these equations x_{pj} is a public program availability measure that affects the mortality rate of poor babies alone and y_j is the fraction of poor women in childbearing ages. Eq. (11) contains the assumption that the mortality rate of non-poor babies does not vary among counties, but this can be modified with little loss in generality. In eq. (12) a program measure such as family planning availability is allowed to affect the function of births to poor women. Presumably, α_1 and γ_2 are negative,[18] γ_1 is positive, and α_0 exceeds β_0. Substitute eqs. (10), (11) and (12) into eq. (9) to obtain

$$d_j=\beta_0+(\alpha_0-\beta_0)\gamma_0+(\alpha_0-\beta_0)\gamma_1 y_j+[(a_0-\beta_0)\gamma_2+\alpha_1\gamma_0]x_{pj}$$
$$+\alpha_1\gamma_1 x_{pj}y_j+\alpha\gamma_2 x_{pj}^2. \tag{13}$$

From eq. (13) the effect of x_{pj} on d_j is

$$(\partial d_j/\partial x_{pj})=(\alpha_0-\beta_0)\gamma_2+\alpha_1\gamma_0+\alpha_1\gamma_1 y_j+2a_1\gamma_2 x_{pj}, \tag{14}$$

and this effect rises in absolute value as y_j rises,

$$(\partial^2 d_j/\partial x_{pj}\partial y_j)=\alpha_1 y_1. \tag{15}$$

Eq. (13) gives a multiple regression of d_j on y_j, x_{pj}, $x_{pj}y_j$ and x_{pj}^2. With more than one public program measure, the regression has an extremely complicated functional form. Specifically, it includes the fraction of poor women, the level of each program measure, the square of that measure, its product with each of the other measures, and its product with the fraction of poor women. Such an equation is not tractable from the standpoint of estimation due to the large set of regressors and severe problems of multicollinearity. Therefore, a truncated version of eq. (13) is fitted in section 4. The specification includes y_j and $x_{pj}y_j$.[19] In the estimation of model 2, the Medicaid, family planning, BCHS project, and WIC variables are interacted with the race-specific fraction of women aged 15 to 44 with family income

[18]As indicated in section 2, the coefficient on x_{pj} in eq. (12) could be positive if the program at issue lowers the price of medical care paid by the poor and therefore lowers the cost of a birth.

[19]The above approach differs from that of Grossman and Jacobowitz (1981). They estimate the fraction of births to low-income women and then fit an equation of the form

$$d_j=\beta_0+(\alpha_0-\beta_0)k_j+\alpha_1 k_j x_{pj}.$$

We do not adopt this procedure because we focus on the reduced form, and k_j is an endogenous variable.

less than 200 percent of the poverty level in 1980. The other variables are not interacted with the fraction of poor women because they reflect determinants of neonatal mortality that are relevant to the non-poor as well as the poor. The means and standard deviations of the eight interaction variables are included in columns (3) and (4) of table 2.

Linear regressions are estimated because a linear specification facilitates the aggregation of the two income specific mortality functions [eqs. (11) and (12)] into a single equation for the entire population. We choose a linear rather than a logistic functional form because the OLS coefficients are more easily interpreted. Maddala (1983, p. 30) argues, in the case of large samples and probabilities not equal to zero or one, that the linear probability function, '. . . is no different in spirit from the log-linear model or the logit model...'. Thus, we do not sacrifice statistical appropriateness by our choice of functional form.

4. Empirical results

Ordinary least squares regressions of white neonatal mortality rates are contained in columns (1) and (2) of table 3, and ordinary least squares regressions of black neonatal mortality rates are contained in columns (3) and (4) of table 3. The regressions in columns (1) and (3) exclude the lagged neonatal mortality rate, while the regressions in columns (2) and (4) include it.

The basic determinants of neonatal mortality in the regressions are female schooling and female poverty levels. For whites, the schooling and poverty regression coefficients have the 'correct signs' and are statistically significant. For blacks, these coefficients also have the 'correct signs' although schooling is insignificant in both specifications.[20]

The six factors or public programs that have been stressed as potential contributors to the acceleration in the downward trend in neonatal mortality since 1964 are neonatal intensive care availability, abortion availability, organized family planning availability, BHCS project availability, WIC availability, and Medicaid. The regressions contain one variable pertaining to each of the five availability programs and five variables pertaining to the Medicaid financing program. Fourteen of the twenty program coefficients have the anticipated negative signs in the white regressions, including eight of the ten availability coefficients and six of the ten Medicaid coefficients. For blacks, nine of the ten availability coefficients and five of the ten Medicaid coefficients have the anticipated negative signs. BCHS project availability has the 'wrong sign' in the two white regressions, and WIC availability has the wrong sign in the black regression that controls for the lagged neonatal

[20]The numerically small and statistically insignificant black schooling effect in column (4) may well reflect the serial correlation bias discussed in section 3, since there is a significant negative partial correlation between schooling and the lagged mortality rate.

Table 3
Regression results.[a]

Variable	White neonatal rates (1)	White neonatal rates (2)	Black neonatal rates (3)	Black neonatal rates (4)
Neonatal death rate (1970)[b]		0.295		0.279
		(9.61)		(6.48)
Percent high school educated[b]	−0.037	−0.017	−0.056	−0.013
	(−3.64)	(−1.76)	(−1.66)	(−0.41)
Percent poor[b]	0.06	0.033	0.036	0.001
	(3.58)	(2.08)	(0.99)	(0.02)
Newborn intensive care hospitals/1000	−44.196	−41.033	−86.196	−53.875
	(−2.61	(−2.59)	(−1.56)	(−1.02)
Abortion providers/1000	−3.198	−3.307	−16.838	−18.297
	(−1.99)	(−2.20)	(−2.94)	(−3.38)
Family planning clinics[c]/1000	−3.605	−2.745	−1.910	−0.532
	(−3.07)	(−2.49)	(−1.29)	(−0.38)
Community health centers[c]/1000	11.726	8.612	−20.515	−14.220
	(2.04)	(1.60)	(−2.13)	(−1.55)
Maternal nutrition program[c]	−0.076	−0.41	−0.043	0.020
	(−2.51)	(−1.44)	(−0.92)	(0.45)
Medicaid eligibility-1[c]	−1.115	−0.485	−0.188	−0.266
	(−2.10)	(−0.97)	(−0.20)	(−0.31)
Medicaid eligibility-2[c]	0.562	0.799	0.627	1.041
	(0.77)	(1.16)	(0.55)	(0.97)
Medicaid eligibility-3[c]	1.101	0.762	−0.355	0.213
	(1.35)	(0.99)	(−0.38)	(0.24)
Medicaid payments for newborn[c]	−0.987	−0.614	−2.972	−1.505
	(−1.05)	(−0.70)	(−2.04)	(−1.08)
Per capita Medicaid payment[c]	−0.01	−0.01	0.002	0.002
	(−0.91)	(−0.42)	(0.94)	(0.86)
Constant	11.432	6.392	20.892	12.477
	(15.30)	(7.30)	(7.67)	(4.33)
R^2	0.120	0.228	0.120	0.216
F	7.53	15.02	3.92	7.28
N	677	677	357	357

[a] t-ratios are in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated each regression is significant at the 1 percent level.
[b] Variable is race-specific.
[c] These variables are interacted with the race-specific percent poor.

mortality rate. Two of the three variables pertaining to Medicaid financing of first-time pregnancies have positive coefficients for whites and for blacks when the lagged rate is held constant. Moreover, Medicaid payments per adult recipient in AFDC families are positively related to neonatal mortality rates in the two black equations. Given the high degree of intercorrelation among the variables in the regression and the imprecise measures used, the preponderance of negative effects is an important and impressive finding.

In terms of statistical significance, the hypothesis that no member of the set of program measures has a non-zero effect on neonatal mortality always is rejected in both specifications at the 1 percent level. With respect to the five specific availability variables, for whites neonatal intensive care, abortion and family planning are significant at the 5 percent level in both specifications. WIC is significant at the 5 percent level in the specification that omits the lagged mortality rate and at the 10 percent level in the specification that includes the lagged mortality rate.[21] In the black regressions, abortion is highly significant, and BCHS projects are significant at the 10 percent level in both specifications. Neonatal intensive care units are significant at the 6 percent level only in the specification which excludes the lagged mortality rate.

Many fewer of the five Medicaid financing variables are significant than the five availability variables. In particular, for both races there are no significant Medicaid effects either taken together or taken separately at conventional levels when the lagged neonatal mortality rate is a regressor. When the lagged rate is omitted from the white regressions, the set of Medicaid variables is significant at the 5 percent level for whites but not for blacks. These results do not necessarily imply that Medicaid is less important determinant of birth outcomes than the other programs. Rather, the results simply may reflect the imprecise Medicaid indexes.

It is notable that the black abortion and neonatal intensive care effects are two to four times larger than the corresponding white effects depending on specification. These results are important because abortion reform and advances in neonatology — unlike WIC, Medicaid, BHCS projects and organized family planning clinics — clearly were not targeted at the poor. Yet the former two developments appear to have had their largest impact on blacks, the group in the population with the lowest income and the largest neonatal mortality rate.

To examine the relative contributions of schooling, poverty, and the program measures to the recent U.S. neonatal mortality experience, we apply the coefficients of regressions in columns (1)–(4) to trends in the exogenous variables between 1964 and 1977.[22] The extrapolations start in 1964 because that year marked the beginning of the acceleration in the downward trend in neonatal mortality. Extrapolations end in 1977 because the regressions

[21]A one-tailed test is employed because the alternative hypothesis is that each coefficient is negative.

[22]The sources for the values of the independent variables in the extrapolations, and the assumptions that underlie these values are available in the appendix to this paper, which is available on request.

pertain to that year. The results of estimating the implied changes in white and black neonatal mortality rates due to selected factors are shown in table 4.

In the period at issue the white neonatal mortality rate declined by 7.5 deaths per thousand live births, from 16.2 to 8.7. The black neonatal mortality rate declined by 11.5 deaths per thousand live births, from 27.6 to 16.1. The statistical analysis 'explains' approximately 28 percent of the white decline on average, with a range between 23 percent and 32 percent. The statistical analysis explains 33 percent of the black decline on average, with a a range between 17 percent and 48 percent.

For blacks, on average, the increase in abortion availability appears to be the single most important factor in the reduction of the neonatal mortality rate. We add a mild caveat to this result because, as discussed in section 3.2, the coefficients on abortion availability may be biased upward by a small magnitude. Even so, the growth in abortion availability appears to dominate not only the other program measures, but also trends in schooling and poverty. The estimated reduction due to abortion amounts to about one death per thousand live births or about 9 percent of the observed decline.

Schooling, Medicaid and neonatal intensive care availability all have similar effects on the decline in black neonatal mortality — between 0.6 and 0.7 deaths per 1,000 live births. It should be noted, however, that neonatal intensive care availability is much less sensitive to the model's specification. Poverty and BCHS projects contributed between 0.20 and 0.25 fewer deaths per 1,000 live births. Again, the program is less sensitive to the model's specification. Finally, family planning and the WIC program account for the smallest, but not insignificant, decline in neonatal deaths.

Table 4
Contribution of selected factors to reduction in neonatal mortality rates, 1964–1977.[a]

	Whites			Blacks		
Factor	(1)	(2)	Mean effect	(3)	(4)	Mean effect
Schooling	0.618	0.284	0.451	1.170	0.272	0.721
Poverty	0.432	0.238	0.335	0.445	0.012	0.229
Neonatal intensive care	0.442	0.410	0.426	0.776	0.485	0.631
Abortion providers	0.178	0.185	0.182	0.943	1.025	0.984
Family planning	0.177	0.135	0.156	0.197	0.055	0.126
Community health centers	−0.059	−0.043	−0.051	0.287	0.199	0.243
Maternal nutrition program	0.538	0.290	0.414	0.636	−0.296	0.170
Medicaid[b]	0.437	0.280	0.359	1.044	0.220	0.632
Total explained reduction	2.763	1.779	2.272	5.498	1.972	3.735
Percent explained	36.8	23.7	30.3	47.8	17.1	32.5

[a]Deaths per 1,000 live births.
[b]Combined contribution of all Medicaid variables.

The results of the white extrapolations are less dramatic than those of the blacks and less clearcut. The increase in white female schooling makes the largest contribution to the decline in white neonatal mortality (about 0.5 deaths per thousand live births). The schooling factor is followed in importance by neonatal intensive care availability, poverty and Medicaid (between 0.3 and 0.45 deaths per thousand live births each). The rise in the WIC program and abortion availability ranks as the fifth- and sixth-leading contributiors (0.2 deaths per thousand live births), and the expansion in organized family planning availability ranks seventh (0.16 deaths per thousand live births). Note that the range of black effects is much larger than the range of white effects both in absolute and in relative terms. For blacks, the ratio of the largest effect to the smallest positive effect is almost 7, while for whites it equals 3. Note also that the correlation between the rankings of black and white contributions is positive but not statistically significant. The Spearman rank correlation coefficient is only 0.36. Note finally that the abortion and neonatal intensive care contributions may loom larger in white birth outcomes than the rankings suggest. This is because the estimated effects of these two factors are stable across the alternative specifications. Also note finally that these results focus on the differential impacts of the variables and cannot be interpreted as time series results since our analysis doesn't account for the changes in medical technology and tastes between 1964 and 1980. These changes were numerous and significant and certainly have contributed to the decline in neonatal mortality. In fact, it is not surprising that by ignoring the technological changes over time, we significantly underestimate the reduction in neonatal mortality for both whites and blacks. A time series approach could provide important additional evidence. Unfortunately, data on program measures by year were not available.

To summarize, the extrapolations point to the importance of abortion availability, female schooling, Medicaid and neonatal intensive care availability and to a lesser extent BCHS projects, poverty, the WIC program and family planning in trends in black neonatal mortality between 1964 and 1977. They also underscore the importance of schooling, neonatal intensive care, poverty, Medicaid, and to a lesser extent abortion services, the WIC program and organized family planning clinics in trends in white neonatal mortality for those years.

To the extent that very ill neonates die in the postneonatal period, one can argue that the above findings overstate the importance of neonatal intensive care availability in race-specific birth outcomes. Yet the postneonatal mortality rate has fallen every year since 1964 for both races, suggesting that this argument is not relevant. At the same time, the results do not imply that the construction and subsidization of additional neonatal intensive care units has a more favorable benefit–cost ratio than an expansion in BCHS projects for blacks if, for example, these were competing programs. Although the neonatal intensive care effect exceeds the BCHS project effect by about 0.4 deaths per thousand live births, the costs of these projects probably are smaller than the costs of constructing and maintaining sophisticated neonatal intensive care units. A similar comment applies to the 0.2 deaths per thousand live births differential between the white neonatal intensive care and organized family planning effects. Indeed, the cost of providing appropriate birth control information to poor women undoubtedly is less than the cost of providing them with prenatal and neonatal care services.

Our results can be compared to those contained in the study by Grossman and Jacobowitz (1981). Our estimates confirm Grossman and Jacobowitz's conclusion with respect to the key role of abortion in black birth outcomes. Our schooling effects are somewhat larger than theirs, which implies that this variable may operate by influencing the mix of inputs selected by families to produce healthy infants. Finally, we provide evidence of the roles of neonatal intensive care units, WIC, and BCHS projects in birth outcomes, which is not contained in their study.

Our results are relevant to the actual and potential impacts on neonatal mortality of a number of dramatic policy reversals by the Reagan Administration since the beginning of 1981. We refer to budget cutbacks which curtailed the rates of growth in such programs as WIC, Medicaid, BCHC projects, and subsidized family planning services. When inflation is taken into account, the absolute size of some of these programs declined in real terms. In spite of these cutbacks, the infant mortality rate declined from 12.6 deaths per thousand live births in 1980 to 11.2 deaths per thousand live births in 1982, and the neonatal mortality rate fell from 8.5 deaths per thousand live births in 1980 to 7.6 deaths per thousand live births in 1982.[23]

Why did the infant mortality rate continue to fall after 1980? Our results suggest that the detrimental effects of reduced spending levels for social programs may have been more than offset by the continued growth in abortion availability,[24] neonatal intensive care availability, and female schooling levels. Of course, the cutbacks may have lagged impacts on neonatal mortality. In any event our findings imply that the program reductions may have retarded the rate of decline in the neonatal mortality rate of the poor since 1980.

Our results also are relevant to the current U.S. policy debate with respect to attempts by the Right to Life movement and its supporters in Congress to outlaw abortion except when it is necessary to preserve a pregnant woman's life. During the past few years, the anti-abortion movement has tried to achieve this goal either by means of a constitutional amendment or an act of

[23]Race-specific data are not yet available for years after 1980.

[24]Recall that Cates (1981) reports that the ban on Federal funding of abortions under Medicaid has had little impact on the number of abortions obtained by low-income pregnant women.

Congress. Our estimates indicate that, if these efforts are successful, neonatal mortality, especially among blacks, may fall slower than otherwise and may even rise.

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