A Limited Benefit-Cost Analysis of Prenatal Care Controlling for Self-Selection

by

Geoffrey F. Joyce

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1995

UMI Number: 9605608

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

9/14/95
Date

Michael Grossman
Chair of Examining Committee

9/14/95
Date

Linda Edwards / m.g.
Executive Officer

Michael Grossman

Linda Edwards

Robert Kaestner

Supervisory Committee

The City University of New York

Abstract

A Limited Benefit-Cost Analysis of Prenatal Care Controlling for Self-Selection

by

Geoffrey F. Joyce

Adviser: Professor Michael Grossman

This study is a limited benefit-cost analysis of prenatal care. The dataset consists of vital statistic records linked to discharge abstracts of delivery and postnatal care for more than 47,000 mother/infant pairs. The sample consists of low income women predominantly covered by Medicaid who delivered at municipal hospitals in New York City between 1990-1992. I estimate the total effect of prenatal care on infant costs and hospital length of stay as well as the direct effects of care not operating through birth weight. Prenatal care is measured by a modified version of the Kotelchuck index. The index is amended by adding a fifth category for women who receive no care prior to delivery. The new index highlights the role of selection bias in the decision to seek care and yields dramatically different estimates of the effectiveness of care than the Kessner index.

I find the direct effects of care on infant costs are negligible when estimated by OLS. However, estimation by instrumental variable techniques and sample selection methodologies yield large and significant effects among blacks and Hispanics. Infants born to black and Hispanic women receiving no prenatal care have considerably higher costs and extended stays relative to mothers who receive adequate prenatal care. The effect of care remains positive and significant controlling for birth weight. Furthermore, I find strong evidence of adverse selection in the decision to seek care among women who receive the most intense prenatal services as well as those who abstain from care. The marginal benefits of providing additional care are largest for women who receive no prenatal services, but are positive and significant for women receiving inadequate or intermediate levels of care. This contrasts with previous work which finds small marginal benefits beyond a threshold level of services.

Acknowledgements

I thank Linda Edwards for her patience and helpful comments throughout the past year, as well as Robert Kaestner for his overriding concern for my economics education. Special thanks to Michael Grossman and Ted Joyce as teachers, mentors, and employers. Their generosity and consideration towards me have been limitless. Finally, I want to thank Claire for all her love and support (as well as some tables).

Table of Contents

Chapter

List of Tables

List of Figures

I. Introduction

The impact of prenatal care on birth outcomes is one of the most widely studied topics in infant health. A large body of empirical evidence over the past three decades has led to a consensus that early and frequent prenatal care reduces the incidence of low birth weight and infant mortality. The evidence accumulated despite divergent trends in prenatal care use and rates of low birth weight. Since 1975, there has been a modest improvement in the percent of pregnant women receiving first trimester care and overall use of prenatal services has increased. However, over the same time, incidence of low birth weight and preterm births are appreciably unchanged. In fact, recent reductions in infant mortality rates in the U.S. are almost entirely due to advances in neonatal technologies.

There are two consequences of these trends. First, government expenditures on infant health are rising dramatically. Recent expansions in Medicaid eligibility for pregnant women have caused the percentage of births covered by Medicaid to rise from 14 percent in 1985 to 32 percent by 1991 (Frost et al, 1993). Approximately 35 percent of expenditures on infant health are devoted to the treatment of low birth weight infants, and nearly half of that amount is used to care for a relatively small percentage of exceptionally small newborns (Shiono et al, 1995). In a sample of 28 urban hospitals with neonatal intensive care units (NICU), low birth weight infants comprised 9 percent of all births, yet consumed 57 percent of newborn costs (Schwartz, 1985).

A second, perhaps more important concern, is that advances in neonatal technologies may not alleviate the long term consequences associated with low birth weight. Infants weighing less than 2500 grams at birth are more likely to experience childhood health problems, delayed cognitive development, lower educational attainment and reduced lifetime earnings, and there is little clinical evidence that neonatal technologies improve long term outcomes (Grossman and Edwards, 1979). The personal and monetary costs of low birth weight are so considerable that relatively inexpensive preventive measures such as early prenatal care seemingly pay for themselves.

In a widely cited review of the cost-effectiveness of prenatal care, the Office of Technology Assessment (OTA, 1988) confirmed the prevailing sentiment of the time. The panel found that each dollar spent on prenatal care saves $3.38 in long-term costs, a number which quickly became a standard reference in the literature. However, in a recent review of prenatal care use, Huntington and Connell (1994) found only twelve studies published between 1975 and 1993 which specifically address costs and cost savings associated with greater levels of care. Although the vast majority of the studies report benefit-cost ratios greater than one, the authors found methodological shortcomings in all twelve analyses. Care may pay for itself, they conclude, but the existing evidence is not reliable enough to support such a claim.

The pendulum once strongly in support of care has begun to swing back. Initial assessments of Medicaid expansions to poor and near-poor pregnant women have been disappointing. Pre- and post analyses from several states report little to no change in prenatal care utilization and newborn health (Haas et al, 1990; Piper et al, 1993; Braveman et al, 1993; Connell et al, 1993; Currie and Gruber, 1993). Even researchers who found care to be cost-beneficial in earlier work recently acknowledged how little we know about the effectiveness of care and how difficult it is to obtain consistent estimates (Alexander and Korenbrot, 1995).

Could such voluminous evidence in support of care be misleading? Economic research in infant health has focused on theoretical and methodological problems which may limit the usefulness of prior work. Prenatal care can affect birth outcomes by moderating maternal behavior with respect to smoking, nutrition and weight gain. Furthermore, early prenatal care can help detect pregnancy complications and identify women with the most to gain (Fuchs, 1982). Empirically, however, it is extremely difficult to separate the impact of care from the effects of unmeasured or unobserved factors correlated with both the demand for care and newborn health. Specifically, women may self-select into different levels of care based on their assessment of the health of the pregnancy, confounding the true relationship between birth outcomes and prenatal care use. Mothers who anticipate a problematic pregnancy may seek more prenatal care to offset poor health endowments. On the other hand, women who lack access to providers, use illicit substances during pregnancy, or invest less in their own health are more likely to get inadequate prenatal care and deliver a low birth weight infant, although birth outcomes for such mothers may have been poor regardless of the level of care (Decker and Gruber, 1993). In sum, the non-random nature of health endowments and other unobservables are likely to be correlated with the demand for prenatal services making it difficult to obtain true estimates of the effect of care.

Controlling for the effect of unobservables is in essence an identification problem, and recent research has focused on finding appropriate instruments. Two-stage methodologies which attempt to control for unobserved heterogeneity have found the effectiveness of care to be considerably larger than OLS estimates, concluding that adverse selection is the predominant bias. However, some clinicians and public health researchers contend that favorable selection may be a more serious source of confounding (Joyce 1994). The net result is that after three decades of research, we know very little of how care operates or which components are most effective.

Aim of the Study

The principal aim of this analysis is to measure the direct effects of care on newborn costs, and to test the sensitivity of the estimates to several theoretical and empirical assumptions used in previous research. I will estimate the effect of prenatal care on different measures of newborn costs by OLS, presuming prenatal care and birth weight are exogenous. I will then use two-stage least squares and sample-selection methodologies to control for simultaneity and omitted variable biases. The parameter estimates will be used to calculate benefit-cost ratios associated with different levels of care.

This study differs and improves upon previous work in several ways. First, I examine two measures of infant costs associated with delivery and postnatal care. Prior work in infant health has almost exclusively used birth weight as the dependent variable and presumed that care operates indirectly. Using individual hospital charges and hospital length of stay as dependent variables allows me to estimate the direct effect of care on newborn costs, independent of birth weight. Positive direct effects would suggest that previous estimates underestimate the total impact of care.

A second distinction of this work is use of a new index of adequacy of care (Kotelchuck 1994). Previous studies have relied almost exclusively on the Kessner index as the critical right-hand side variable. The index was considered a major improvement over one dimensional measures, classifying the adequacy of prenatal care as adequate, intermediate or late based on both month of initiation and frequency of visits. However, the Kessner index is dominated by timing of care and fails to adequately distinguish between vastly different groups of women. In contrast, I use a modified version of the Kotelchuck index to measure adequacy of prenatal care. The Kotelchuck index adds two additional categories, separating women who receive more than expected prenatal services and those who abstain from care. Birth outcomes of these women are dramatically different from those in the other three categories of care. This distinction underscores the role of selection bias in the decision to seek care and identifies women most likely to gain from government health policies. In sum, the Kotelchuck index is a vastly different measure of care and leads to significantly different conclusions regarding the effectiveness of care in improving newborn health.

The majority of previous benefit-cost analyses estimate the gains to care using aggregate charges or make unsupported assumptions regarding the effectiveness of care in reducing the incidence of low birth weight. In contrast, this analysis uses a unique dataset that links detailed vital statistic records to discharge abstracts for each mother/infant pair, permitting me to directly estimate the impact of prenatal care on various measures of newborn costs. The sample consists of low income, urban women who experience rates of low birth weight far above national averages. Any attempt to significantly improve infant mortality in the U.S. and reduce health expenditures for newborns must address the determinants of care and their impact on infant health among this subpopulation. I restrict the analysis to delivery and postnatal period. This restriction may underestimate the long-term benefits of care, but avoids making tenuous assumptions to estimate long term costs and benefits.

The importance of this research is underscored by the enormous costs associated with adverse birth outcomes and the paucity of reliable benefit-cost analyses to date. There is a general belief that we spend far too much money on interventionist obstetrical care and not enough on basic primary services such as prenatal care. The questions the study seeks to address are both methodological and policy oriented. Can we realistically separate the gains to care from unobserved factors and if so, do the benefits of early and frequent care outweigh the costs of providing those services?

II. Literature Review

Many variables which affect newborn health are largely beyond the scope of public health policy. Factors such as prepregnancy health, obstetrical history and biological endowment are for the most part fixed (Racine et al, 1992). As a result, greater emphasis has been placed on factors which policy can affect, specifically, improved access and utilization of prenatal care. The recent expansions in Medicaid eligibility for pregnant women are intended to broaden access to care among a relatively high risk population.

The following section is a brief summarization of empirical findings from the medical and public health literature encompassing four areas of research: determinants of prenatal care, the effectiveness of care in improving birth outcomes, results from recent Medicaid expansions, and previous cost-benefit analyses of prenatal care. We then focus on theoretical and methodological issues of care within the economics literature. We separate medical and public literature given their emphasis on different approaches and methodologies to the study of infant health.

A. Medical and Public Health Literature

1. Demand for prenatal care

Previous research has identified a common set of factors correlated with prenatal care use. Higher educated, insured, foreign born women receive more care on average, as do whites, older mothers and those giving birth for the first time. Women who use illicit drugs during pregnancy are far less likely to receive adequate care, as are mothers who have delivered three or more previous births.

A number of studies have directly addressed the determinants of prenatal care among poor and near-poor pregnant women. Low income women typically receive less prenatal care and are more likely to experience adverse birth outcomes than higher income mothers, highlighting financial barriers to care and the role of insurance on newborn health. Poland et al. (1987) attempt to identify the main socio-cultural factors affecting demand for care among a sample of low income women. Six factors explain nearly half of the variation in use between women receiving adequate versus inadequate care. The most significant factors are insurance status, attitudes towards health professionals and wantedness of pregnancy. In similar research using a case-control study, Melnikow and Alemagno (1993) compare women receiving inadequate prenatal care to a control group which receives intermediate or adequate care as measured by the Kessner index. They find lack of health insurance is the most important distinction between groups, while homelessness, race, wantedness and maternal attitudes towards health care are also significant risk factors.

Both studies lack a set of variables to adequately control for observed differences between groups, but the results identify a range of non-financial barriers affecting the decision to seek care. Low income women are less likely to have a relationship with a health care provider, more likely to have an unwanted pregnancy and may underestimate the marginal product of medical care. The results suggest that although health insurance is an important determinant of prenatal care use, there are a set of non-financial barriers which are rarely addressed by government health policies.

The content of prenatal care is often ignored in empirical work since most large datasets lack information beyond month of initiation and total number of visits. Yet, variations in the quality of care may be more significant than differences in quantity. Buescher et al (1987) compare women receiving comprehensive prenatal services through a special Department of Health (DOH) program to Medicaid recipients served by private physicians. The results of their analysis are striking. The Medicaid group initiates care earlier and has more visits on average than DOH women, however, the rate of low birth weight of the latter is less than half of the control group (8.3% vs. 19.3%). The dramatic differences in birth weight may reflect underlying health differences between groups not adequately controlled for in the analysis. The authors lack controls for smoking, drug use, insurance status, and nationality, important determinants of prenatal care use and birth outcomes and likely to be correlated with included regressors. Nevertheless, the results strongly suggest that quality of care is an important determinant of birth outcomes.

Reichman and Florio (1995) employ a cross sectional design to analyze New Jersey's Healthstart program. Healthstart offers Medicaid recipients more comprehensive prenatal services, presumptive eligibility and greater integration with other social services. At the same time, the program offers providers a more reimbursement schedule to increase the availability of services to low income women. They find that Healthstart raises first trimester initiation of prenatal care and increases birth weight among blacks, but has only a modest and less consistent effect on whites.

The effectiveness of enhanced prenatal services is less evident in two studies by Peoples et al (1984) and Strobino et al (1986). Both analyses examine the effects of more comprehensive services on the frequency of prenatal visits and birth outcomes. The projects offer improved prenatal care to women living in previously underserved areas. In both cases, they find significant improvements in prenatal care use, but no corresponding effects on birth outcomes.

2. Effectiveness of Prenatal Care on Birth Outcomes

There is considerable evidence to support the effectiveness of prenatal care in improving birth outcomes. Reviews by the Institute of Medicine (IOM, 1985) and the Office of Technology Assessment (OTA, 1988) provide comprehensive summaries of research through the mid-1980's. The sheer volume of evidence is compelling, and it led to a consensus that early and frequent care are effective ways to reduce the incidence of low birth weight. The evidence is not unanimous, however. In this review, I will briefly examine a set of studies in which the gains to care are small or insignificant. I refer readers to the two articles cited above for a more comprehensive review of the literature.

Despite voluminous research in this area, there is little understanding of how prenatal medical care affects the biological process. Prenatal care can affect newborn health by extending gestation and accelerating intrauterine growth. Physician advice, especially early in pregnancy, can hasten intrauterine growth by moderating known risk factors such as smoking and poor nutrition, while early detection and treatment of complications can prevent or modify the consequences of preterm delivery.

Hall et al (1980) retrospectively examine antenatal and delivery records of over 2100 British women who gave birth in 1975 to test the efficacy of prenatal care in identifying pregnancy complications. They focus on three common problems: intrauterine growth retardation, malpresentation (breech), and pre-eclampsia. They find the majority of antenatal admissions to hospitals, aside from delivery, are for conditions not detected or prevented by prenatal visits. Only 44 percent of cases of intrauterine growth retardation are detected in prenatal visits, while 30 percent of pre-eclampsia cases are discovered during delivery or immediately thereafter. In addition, they find evidence of over-diagnosis. There are roughly two and a half false positives for every true case of intrauterine growth retardation.

In more recent work, Tucker er al. (1991) examine the cause of preterm births in a large sample of predominantly black, indigent women. They find only 23 percent of preterm births are deemed "preventable", and in these cases, the majority of mothers arrive at the hospital at 3 cm. or more dilatation. The authors conclude that significantly reducing preterm birth rates is not a realistic goal given current identification and treatment strategies.

To compare the effectiveness of care in complicated versus uncomplicated pregnancies, Mustard and Roos (1994) examine a large cross-section of births to

Canadian women who are registered with the Manitoba Health Services Insurance Plan. All the women receive universal health insurance and pregnancy complications are identified by ICD-9-CM diagnostic codes. Prenatal care utilization is high on average: women receive eleven prenatal visits and initiate care in the seventh week of pregnancy. Utilization varies by income but overall utilization is high in relation to comparable U.S. women. Mustard and Roos find that prenatal care is no more effective in complicated than in uncomplicated pregnancies. The differential mean birth weight between women receiving adequate versus inadequate care is 72 grams in complicated pregnancies and 73 grams in uncomplicated births. The authors offer four possible explanations for the results. First, adequate prenatal care may impact on newborn health in ways not measured by birth weight. Interventions that extend gestation and fetal maturity, but do not enhance birth weight, will not be captured in their analysis. Second, they do not test whether antenatal care prevents the onset of complications. Third, lumping a wide range of complications into a single measure may obscure successful interventions. Finally, the authors acknowledge they may not adequately control for underlying differences across groups, confounding the true relationship between prenatal care use and birth outcomes.

In most cases, low birth weight infants are either born prematurely, grow too slowly in utero or some combination of the two. While there is considerable knowledge of the determinants of fetal growth, the etiology of prematurity is uncertain (Paneth, 1995). Economic research in the early 1980's found care to more effective in prolonging gestation than in accelerating growth (Harris 1982; Rosenzweig and Schultz

1982, 1983). However, more recent evidence by Tucker et al (1991) suggests prematurity is often unpreventable. Furthermore, there is little content in a typical prenatal visit that directly affects intrauterine growth. In other words, the large body of evidence in support of care is less conclusive in light of how little we know of how care operates and how it impacts on newborn health.

3. Effect of Medicaid Expansions on Newborn Health

State expansions in Medicaid eligibility over the past ten years are a response to alarming trends in health coverage of low income families. Medicaid coverage has long been tied to AFDC eligibility. As AFDC thresholds declined in real terms, the number of children without health insurance rose. From 1982 to 1986, the number of children under 6 years of age who live in poverty increased 15.2 percent, and the number without health insurance rose by over 20 percent. The consequences of rising poverty and inequality became increasingly evident, prompting congressional legislation to expand Medicaid eligibility to pregnant women and their young dependents. This legislation broke the link between Medicaid and AFDC and led to dramatic increases in the number of births covered by Medicaid (HCFA Statistical Supplement, 1995). As of 1991, nearly one-third of all births are insured by Medicaid, more than double the 1985 rate (Frost et al, 1993).

Researchers have anxiously sought to measure the impact of the Medicaid expansions for they reflect an exogenous shift in eligibility. This permits researchers to estimate the impact of care on newborn health uncontaminated by selection bias. Pregnant women and their physicians may have some information regarding the health of the pregnancy which alters their demand for prenatal care. This correlation between fetal health and prenatal care use confounds the true effect of care. Cross-sectional analyses which attempt to control for selection generally find OLS underestimates the gains to care. In other words, prenatal care is more effective in studies that control for unobserved differences among women. Initial results of the Medicaid expansions are a sharp contrast to previous work. Pre- and post analyses from several states report little to no change in prenatal care use and birth weight. The one exception is a study by Currie and Gruber (1994).

Piper et al (1990) examine the impact of Medicaid expansions across different age and racial groups in Tennessee. The expansions lead to substantial increases in enrollment for specific groups of women, but do not lead to greater utilization of care or improved birth outcomes. Medicaid eligibility in Tennessee was extended to married, low-income women. Enrollment increased 18 percent for white, married women under 25 years of age without a high school diploma, but did not significant alter prenatal care use. The results may have been affected by three factors. First, more than two-thirds of women enrolled after the first trimester, limiting the beneficial effects of coverage. Second, Piper et al. do not control for secular trends. Third, they evaluated the expansions shortly after their introduction. Comparing birth outcomes one year before and after the changes may not be a sufficient period of time to assess the full impact of the expansions.

Braveman et al (1993) estimate the probability of receiving no prenatal care, untimely care and less than adequate visits for three groups of women who differ by insurance status. They compare outcomes of uninsured, Medicaid, and privately insured women in response to recent expansions in Medicaid eligibility thresholds. Medicaid expansions in California raised eligibility thresholds to 185 percent of poverty in July 1989, and to 200 percent by January 1990. Braveman et al report that uninsured and Medi-Cal recipients are far more likely to have untimely care relative to privately insured women, and Medi-Cal recipients are three times more likely to receive insufficient care. Although the expansion improved the continuity of care, Medi-Cal women do not receive as much care as privately insured women. The authors note the effects of the expansions may have been restrained by capacity constraints. System capacity did not keep pace with large increases in eligibility, thereby raising waiting times and the total cost of care.

Haas et al (1993) examine the impact of expanded health coverage on Healthy Start participants in Massachusetts from 1984 to 1987. In 1984, the Medicaid program covered women up to 100% of the federal poverty level in Massachusetts. Healthy Start provided coverage for those ineligible for Medicaid and whose income did not exceed 185% of the federal poverty line. Haas et al compare initiation of prenatal care and birth outcomes of uninsured and Healthy Start women to Medicaid and privately insured women. A major limitation of their study is that they could not identify women who would have been eligible for Healthy Start in 1984 had the program existed, and thus they compare all uninsured women in 1984 to uninsured and Healthy

Start women in 1987. The impact of Healthy Start is biased downwards if the health status of the uninsured deteriorates or if access to care for uninsured women declines over the 3 year study period. This may have occurred, as Healthy Start had no impact on either initiation of care or birth outcomes.

Currie and Gruber (1994) use aggregate vital statistic records to estimate the effect of the expansions on the incidence of low birth weight and infant mortality. A key component of their study is a "simulated" measure of eligibility, which circumvents the difficulties of adequately controlling for state and year differences. They find that increases in Medicaid coverage are half as large as increases in eligibility, a lower take-up rate in comparison to other government transfer programs. However, they find that higher eligibility raises utilization of medical care and reduces child mortality.

It is far to early to draw conclusions from the recent expansions, yet the majority of results to date show modest to insignificant effects on prenatal care use and birth weight. Currie and Gruber (1993) suggest that low take-up rates may be due to the characteristics of those eligible as a result of the expansions. The newly eligible may be less needy and perhaps less familiar with social assistance programs, and thus the stigma of Medicaid may be a strong deterrent to enrollment. Cutler and Gruber (1995) hypothesize that small improvements in birth outcomes due to the expansions may be a result of "crowding out" of private insurance. Either employers choose not to offer insurance or employees refuse private coverage once eligible for public insurance. Thus, the newly eligible are those who were previously insured rather than uninsured.

4. Benefit-Cost Analyses of Prenatal Care

Huntington and Connell (1994) review over 100 refereed articles published between 1975-1993 on the effectiveness of prenatal care. Only twelve articles explicitly discuss costs or cost savings associated with greater levels and the authors find methodological shortcomings in all of the analyses. The authors categorize the twelve studies into three groups: four based on natural experiments, four cross-sectional analyses, and four studies using synthetic or hypothetical calculations of cost savings. Among the latter group, the Institute of Medicine (IOM, 1985) and the Office of Technology Assessment (OTA, 1988) analyses are the most widely cited. The IOM study targets pregnant women on public assistance, aged 15-39 with less than 12 years of schooling. These women are at exceptionally high-risk of receiving inadequate prenatal care and experiencing adverse birth outcomes. The IOM study computes costs as the sum of expenditures on intensive care, rehospitalization costs during the first year, and a single year estimate of the annual long-term expenses of those who survive the first year of life and do not require institutionalization. They assume the additional cost of providing prenatal care is equal to the current average charge for routine care in the U.S. Benefits are measured by estimating the net savings from lowering the current rate of low birth weight among the target population from 11.5 percent to somewhat arbitrary rates of 10 and 9 percent. The IOM analysis provides no evidence concerning the feasibility of the proposed reductions. In fact, high risk populations similar to the IOM study group show modest to insignificant improvements in prenatal care utilization in response to expansions in Medicaid eligibility.

The OTA study asks a similar question, yet in reverse. How much of a reduction in low birth weight is necessary to cover the cost of providing additional care? Again, no attempt is made to support the likelihood of the reductions. The relationship between provision and utilization of prenatal care is not deterministic and simply cannot be inferred to estimate the net benefits of care, nor can one presume that increases in prenatal care use will lead to specific improvements in newborn health.

Two other "synthetic" studies by Schwartz (1989) and Gorsky & Colby (1989) find benefit-cost ratios in excess of 2.0. The Gorsky study follows the same basic methodology as the IOM analysis with two exceptions. The sample is trichotomized by level of education - less than 12 years, 12, and greater than 12, and the target rate of low birth is the average of those receiving adequate prenatal care within each educational group. They find that $1. spent on prenatal care saves $2.57 in delivery and postnatal costs.

Schwartz (1989) examines the costs of treating low birth weight infants in a sample of urban hospitals with neonatal intensive care units (NICU). Over half of low birth weight infants born in the U.S. in 1985 were treated in NICU facilities. Schwartz estimates the benefits and costs of shifting the distribution of birth weights to right. More specifically, she calculates immediate cost savings of $70-$95 million by shifting 20% of births to the next highest category, e.g. 20% of 1250-1499g infants would move into the 1500-1749g interval, etc.... In comparison, the estimated costs of this shift are $9-$28 million, yielding a benefit/cost ratio substantially greater than one.

Four benefit-cost studies are based on natural experiments where the treatment group receives comprehensive services and controls receive routine or no prenatal care. The main criticism of studies by Korenbrot (1984), Lennie et al (1987), Moore et al (1986) and Leppert et al (1985) is the use of noncomparable control groups. The study groups are different in measured and potentially unmeasured ways with respect to income, substance abuse, maternal age, citizenship, and motivation. These differences make it difficult to separate the gains from care from underlying differences between groups. For instance, Leppert et al (1985) do not control for gestational age in measuring the adequacy of prenatal care. Thus, women with preterm births may be incorrectly coded as having insufficient visits based on a schedule for a full-term pregnancy (Huntington and Connell, 1994).

The remaining four benefit-cost analyses are cross-sectional studies. Wilson et al (1992) compare neonatal intensive care admission rates and total costs for women who receive adequate versus inadequate care. Inadequate care is defined as late initiation, or less than five prenatal visits given a minimum gestation of 24 weeks. The authors find that infants with inadequate care are almost twice as likely to end up in NICU and have considerably higher costs of delivery and postnatal care. The results should be interpreted cautiously, however. Women are not randomly assigned to different levels of care, and thus the authors assume receipt of prenatal care is uncorrelated with perinatal risk.

In related work, Boyle et al. (1983) estimate net savings of neonatal intensive care treatment for very-low birth weight infants. The sample consists of two groups: infants weighing 500-1499g born between July 1964 and December 1969 are termed the pre-NICU group, while low birth weight babies born in the same county between January 1973 and December 1977 and treated in NICU's represent the study (NICU) group. Discharge costs are substantially higher for the NICU group. NICU infants weighing 1000-1500g incur costs three times higher than similar children in the pre-NICU group, and 500-999g NICU infants have costs nearly nine times higher. The major finding of the study is that NICU is far more cost-effective among 1000-1499g infants than 500-999g babies. However, treatment in neonatal intensive care fails a strict benefit-cost analysis under every scenario except at discount rates below 3.5% and among higher weight infants (1000-1499g). Although these findings are of considerable interest, long-term cost estimates are greatly hampered by parental recall of children's health status, especially in the pre-NICU group born in the 1960's.

In summary, the medical and public health literature weighs heavily in support of early and frequent prenatal care use and its effectiveness in improving birth outcomes. However, many questions remain unanswered. Why have improvements in prenatal care use over time not led to decreases in the incidence of low birth weight and prematurity? Do the modest improvements in birth outcomes due to the Medicaid expansions reflect declining marginal benefits? What components of care are most effective and how do they accelerate intrauterine growth or prolong gestation? Finally, can cross-sectional analyses adequately control for unobserved differences among women? In the next section, I briefly review economic research on the effects of prenatal care.

B. Economic Literature

1. Theoretical Issues

The theoretical framework underlying the demand for health incorporates the theories of human capital and consumer behavior. Grossman (1972) applies the work of Becker (1965) and Lancaster (1966) to the demand for health and the derived demand for medical care. In Grossman's model, health has both consumption and investment components. Health is a consumption good because it directly affects utility and an investment good since it minimizes lost market time, thereby raising utility by increasing income. Individuals augment their stock through investments in health.

An important distinction of the model is that some goods and services do not enter the utility function, rather they serve as inputs into the production of commodities which are the true objects of utility (Willis, 1973). In the case of health, individuals produce the commodity good health with their own time and the purchase of inputs such as medical care. Medical care does not directly affect utility, thus its demand is derived from the production functions of health and other commodities, input prices and the demand for health (Grossman, 1972).

Becker (1960) was the first to apply an economic framework to fertility decisions, using the value of parents foregone opportunities to measure the costs of childbearing. Willis (1973) extended this framework in the development of a theoretical model of marital fertility. Infant health is an aspect of child quality. Parent's make decisions regarding optimal family size and child investments, commonly referred to as the quality/quantity tradeoff. High income families tend to have fewer children, but invest more in each child (Becker and Lewis, 1973). Given certain assumptions, the model allows researchers to test the effect of wage changes or education level on the demand for children and child health.

Lewit (1983) distinguishes between fixed and variable time costs of pregnancy to predict the effects of price and income changes on birth outcomes. Variable time costs of pregnancy are a function of parental choices such as doctor visits, birthing classes, and rest, whereas fixed costs reflect foregone income and time away from market activities. With higher opportunity costs, better educated, more affluent households may bear fewer children or may make smaller investments prenatally in their child's health. On the other hand, better educated women may be more efficient in both market and non-market settings, allowing them to make larger contributions to infant health through more productive use of inputs (Michael, 1972; Grossman, 1972). Under certain restrictions imposed by the model, Lewit shows that parents will offset a poor health endowment by increasing their demand for health inputs. This is an important theoretical prediction, for researchers have long suspected that the decision to seek care is correlated with the health of the fetus.

Rosenzweig and Schultz (1982, 1983) clarify the distinction between structural production functions and input demand equations. The production of infant health is directly affected by health inputs. However, the demand for inputs may be affected by the biological endowment or health of the pregnancy. Models which fail to incorporate the potential endogeneity of health inputs are likely to be biased.

Following Rosenzweig and Schultz, let household utility (U) be a function of 3 types of goods: infant health (H), goods that affect infant health and yield utility (Y) such as smoking, and non-health related goods (X):

$$(1)\quad U = u(X_i, Y_j, H) \qquad i=1,\ldots n; \qquad j=n+1,\ldots m$$

The family does not maximize infant health, but treats it as one source of utility (Fuchs, 1982). The production of infant health is characterized by (2),

$$(2)\quad H = h_2(Y_j, I_k, \mu) \qquad k=m+1,\ldots,r$$

where I_k represents health inputs such as prenatal care which do not directly affect utility and μ captures family health endowment. Parents have at least some knowledge of the family-specific endowment such as genetic traits or obstetrical history, but they are assumed fixed. An important distinction of this model is the inclusion of Y_j in both the utility and production functions. This permits goods such as cigarettes and illicit drugs to affect both infant health and parent's utility. Finally, let (3) represent the budget constraint for the household.

$$(3)\quad F = P_x X + P_y Y + P_I I$$

Maximizing the utility function subject to production and resource constraints yields a reduced form demand function for infant health (4),

$$(4)\quad H = h_4(P_x, P_I, P_z, F, \mu)$$

where infant health is a function of prices and income. The focus of empirical work has been on the demand for health inputs (Goldman and Grossman, 1978; Leibowitz and Friedman, 1979), since estimation of the structural production function is limited by the availability of data on a wider range of health inputs. Rosenzweig and Schultz (1982, 1983) argue that "hybrid" equations which use income as a proxy for hard to measure inputs are biased. Prior work ignores seemingly large differences in health endowments across individuals and presumes the endowment is uncorrelated with the demand for inputs such as prenatal care.

This assumption is quite tenuous in light of standard clinical procedures such as X-rays, ultrasound, and amniocentesis which provide parents and the physician with almost instantaneous information regarding the health of the pregnancy.

2. Empirical Issues

The correlation between family endowment and the demand for health inputs reflects self-selection in the decision to seek care. Researchers have long suspected that women may alter their choice of inputs based on their assessment of the health of the fetus (Harris 1982, and Rosenzweig & Schultz 1982, 1983). Attempts to control for selection bias have taken three different approaches. The first and most common is to increase the number of covariates or to decrease heterogeneity by analyzing relatively homogenous samples (Showstack et al. 1984; Shiono et al. 1986; Murray and Bernfield 1988; Schoeddorf et al. 1988; Racine, Joyce and Anderson 1993). The aim is to proxy or hold constant hard to measure factors such as nutrition, motivation and adverse behaviors. New York City vital statistics are among the most detailed in the country, and combined with census data provide a relatively large set of control variables. However, it is unlikely they would fully capture unobserved heterogeneity, even among a relatively homogenous sample of low income women.

A second approach is to apply instrumental variable techniques or sample selection methodologies in order to control for the reverse causality between the expectation of an adverse birth outcome and utilization of care (Harris 1982; Rosenzweig and Schultz 1983; Grossman and Joyce 1990; Joyce 1994). The third approach relies on natural experiments in which an exogenous intervention, such as expansion in Medicaid eligibility, increases the utilization of prenatal care (Buescher et al 1991; Connell et al 1993; Currie and Gruber 1994; Haas et al 1993; Piper et al

1994).

The results of these methods are mixed, although difficult to generalize due to differences in measures of prenatal care. Detailed multivariate specifications yield positive effects of prenatal care on birth weight. Two-stage methodologies, which attempt to control for the endogeneity of prenatal care, suggest that single-stage estimation such as OLS substantially underestimate the positive effect of care on birth outcomes. Finally, recent analyses of natural experiments such as the Medicaid expansions reveal modest to insignificant changes in both prenatal care utilization and incidence of low birth weight.

Studies Using Aggregate Data

In three related studies, Corman, Joyce and Grossman (1987), Joyce (1987) and Corman, Grossman and Joyce (1988) examine the determinants of input utilization and their impact on neonatal mortality rates using cross-sectional data. The studies emphasize supply-side variables and their impact on newborn health. Joyce (1987) uses a cross-sectional analysis of U.S. counties in 1977 to examine black neonatal mortality rates. He finds the availability of family planning clinics, abortion providers, community health centers and neonatal intensive care are positively correlated with their utilization, which in turn improves survival rates. A 10 percent increase in the number of family planning clinics per women aged 15-44 would raises adolescent utilization by 1 percent, resulting in five fewer neonatal deaths per 100,000 live births. A similar increase in abortion providers would avert two deaths per 100,000 live births.

Corman, Grossman and Joyce (1987) also use county-level data for the period 1964-1977 to estimate race-specific infant health production functions. The results suggest that use of prenatal care, abortion, WIC participation and neonatal intensive care are the most important determinants of survival. Furthermore, black neonatal mortality rates are more sensitive to the use of these inputs than white rates.

Corman, Grossman and Joyce (1988) employ state data from 1980 to estimate the determinants of birth weight-specific neonatal mortality rates in the U.S. They use two-stage methodologies after rejecting the exogeneity of abortion, smoking and prenatal care. They find availability of abortion and neonatal intensive care units are the most important determinants of overall neonatal mortality. Availability of abortion has a significantly larger impact than NICU among blacks. The authors conclude that greater equality of health resources is extremely beneficial in reducing the wide disparity in neonatal mortality rates between different races and socioeconomic groups.

Frank et al (1992) estimate a fixed effects model with aggregate panel data of U.S. counties to examine the impact of prenatal care on the incidence of low birth weight. Aggregate data eliminates heterogeneity bias unless women with similar health endowments cluster geographically. To control for potential clustering, they use separate intercepts for each county. They cannot reject the exogeneity of prenatal care and thus rely on OLS estimation. Results pertaining to blacks are similar to those of Joyce (1987). Initiation of prenatal care and per capita income are the only significant coefficients among whites, while initiation of care is the lone significant factor affecting low birth weight among blacks. The marginal product of early initiation is larger for blacks than whites, yet the effect is small in absolute terms. Frank et al. estimate that raising black rates of first trimester care to that of whites (24 percent increase) would reduce the rate of low birth weight for blacks from 12.08 percent to 11.79 percent, a gain of 2.4 percent. They conclude that raising rates of early initiation or increasing median income will not dramatically improve the incidence of low birth weight nor the large race differentials in birth outcomes between blacks and whites.

An interesting caveat of their analysis is the race-specific role of selection bias. The coefficients on prenatal care fall dramatically for blacks (in absolute value) and rise significantly for whites when fixed effects are removed. Frank et al interpret this as evidence of adverse selection among blacks, and favorable or positive selection among whites. In other words, black women with relatively poor health endowments are more likely to initiate care in the first trimester, whereas white women with better than average endowments are more likely to seek early prenatal care. This finding contrasts with results of Rosenzweig and Schultz (1983,1988) and Grossman and Joyce (1990). County-level dummies can capture a range of unobserved factors, and thus may explain why their selection results contrast with previous work.

Studies Using Micro Data

The inherent difficulties in accurately estimating individual decision-making with aggregate data have prompted more recent research in infant health which relies on micro data. In this section, I briefly outline a few studies which employ micro-data and two-stage estimation techniques to control for the potential endogeneity of health inputs.

Harris (1982) contends that prior research does not adequately control for the association between prenatal care use and duration of pregnancy. He outlines four scenarios which may bias the role of care. First, women who anticipate problems or a have history of pregnancy complications may seek early and frequent visits, biasing downward the effects of care. Similarly, women with uneventful, healthy pregnancies may seek fewer visits. On the other hand, as a cohort of pregnancies progresses, less healthy fetuses are more likely to be terminated. Thus, the probability of an adverse outcome is reduced for women who delay care until the last trimester simply because the fetus has survived that long. Harris refers to this as "fetal selection". Finally, mothers who are in poor prepregnancy health, lack access to a regular physician, or underestimate the marginal product of medical care are likely to receive less care, although birth outcomes for such women may have been poor regardless of the level of care (Decker and Gruber, 1993). In sum, a confluence of potential biases makes it extremely difficult to obtain consistent estimates.

Using a continuous time stochastic model, Harris finds that prenatal care helps prevent prematurity. In fact, the effect of care on gestation is roughly twice as large as its impact on intrauterine growth. Furthermore, for low birth weight infants, neonatal mortality rates are relatively high for those who initiated care in the first month, and substantially below average for those initiating care in the last trimester.

Harris notes that aggregating mothers with no care and inadequate care would produce a contradictory relationship between care and birth weight specific mortality.

Rosenzweig and Schultz (1982, 1983) take a vastly different approach. They assume maternal age, parity, smoking and prenatal care are endogenous in estimating a birth weight production function. A favorable health endowment may increase the likelihood of giving birth, raise average maternal age, or lengthen delay in seeking prenatal care. Failure to control for these associations will bias parameter estimates. Rosenzweig and Schultz find that prenatal care delay is insignificant when estimated by OLS, but has a large, statistically significant effect when estimated by 2SLS. The most striking finding of their analysis is the impact of cigarettes. They find that smoking at least one pack of cigarettes a day lowers birth weight by 279 grams, or 8.5 percent. In comparison, six months delay in initiating prenatal care reduces birth weight by 45 grams. Cigarettes are strongly correlated with education and income, and the authors argue that differences in birth outcomes across education levels may be due to cigarettes and not other factors. They also estimate a structural equation using birth weight standardized for gestational age as the dependent variable. This permits them to compare the effects of care prematurity relative to its impact on intrauterine growth. Similar to Harris (1982), they conclude that prenatal care has its primary effect on gestation and has little impact on intrauterine growth rates.

Grossman and Joyce (1990) argue that use of instrumental variables to control for self-selection in the choice of inputs presupposes adverse selection and ignores selection in the decision to give birth. They estimate an infant health production function that simultaneously controls for selection in pregnancy resolution and the use of prenatal care. They find evidence of selection in both the birth weight and prenatal care equations for blacks, but no evidence among whites. For blacks, unobserved factors which raise the likelihood of giving birth are positively related to unobserved factors which hasten prenatal care use and increase birth weight. Furthermore, prenatal care is exogenous after controlling for selection in the choice of inputs.

Rosenzweig and Schultz (1991) examine the distribution of prenatal medical services among pregnant married women in the U.S. Sample statistics reveal large inequities across race and socioeconomic level. Blacks are 40 percent less likely to receive an X-ray than whites, but nearly 20 percent more likely to have a Caesarean section. Women from higher income households were more likely to have amniocentesis and ultrasound. The tax subsidization of health expenditures alters the price of medical care unevenly, and thus influences the demand for and distribution of prenatal services. After controlling for underlying health and income differences, the disparity in ultrasound and X-ray services increases, whereas the differential use of amniocentesis and caesarean-sections declines. The authors reject the hypothesis that the provision of medical services is based solely on need. Rather, taxes and transfers lower the implicit price of medical care more dramatically for higher income households, thereby exacerbating differentials in the use of certain technologies.

Economic research over the past two decades has greatly improved the theoretical framework for modelling the demand for inputs and the production of infant health. However, many methodological and empirical questions persist. The efficiency of two-stage estimates relies on valid instruments with ample explanatory power, often difficult to find in empirical studies. For instance, Rosenzweig and Schultz (1983) endogenize four inputs, with first and second stage R-squares between .03 and .12. Subsequent work has shown that two stage estimates with poor instruments may be less efficient than OLS (Bound et al, 1995; Bollen, Guilkey and Mroz, 1995).

The positive effect of care in improving birth outcomes is generally larger using two-stage methodologies, confirmed by most selection models that find OLS underestimates the gains to care. However, these models are not robust nor consistent across races or age groups.

In Section III, I describe and compare two measures of prenatal care use: the Kessner index (IOM, 1973) and a modified version of the Kotelchuck index (Kotelchuck, 1994). The two indices are dramatically different and lead to vastly different conclusions regarding the effectiveness of care and the role of selection bias. In section V, I present parameter estimates of cost and stay equations using both indices.

III. Measurement of Prenatal Care

The most widely used measure of prenatal care adequacy is the Kessner index (IOM 1973). This index was the first to combine timing and utilization into a single construct, and was believed to be a vast improvement over one dimensional measures of prenatal care such as number of visits or months of delay. Women are categorized as receiving adequate, intermediate or late prenatal care based on trimester of initiation. The rating can be lowered, but not raised, depending on the number of prenatal visits a women receives. For instance, a woman who initiates care in the first trimester is classified as having received adequate prenatal care, unless she receives fewer than 9 visits for a normal length pregnancy. In that case, her rating is lowered to intermediate care. A recent critique of the Kessner index highlights three significant shortcomings. First, the index is dominated by trimester of initiation. Only 13.8 percent of women have their rating reduced due to insufficient visits (Kotelchuck, 1994a). Second, the index does not distinguish between inadequate care resulting from insufficient visits and inadequacy due to delayed initiation. Nearly 25 percent of women would be categorized differently if the two were measured separately. Finally, full-term births can be categorized as adequate even if they fall short of standards set by the American College of Obstetrics and Gynecology (ACOG). The Kessner index codes visits to one digit. Thus, nine or more prenatal visits are coded as "nine." Women delivering at 39 weeks gestation should receive 13 visits by ACOG standards, but would be categorized as having received adequate care by the Kessner index if they initiated care in the first trimester. Kotelchuck (1994) calculated that 44 percent of all women would be categorized as having a lower classification of care if this were corrected.

Kotelchuck proposed a new index which uses the ratio of actual to recommended number of prenatal care visits, conditional on when care began, and the length of pregnancy, to characterize the adequacy of prenatal care visits (Kotelchuck 1994a). Thus, researchers can associate the adequacy of initiation, the adequacy of utilization, or a combination of the two dimensions with various measures of newborn health. In this analysis, we combine the two dimensions into a single index of adequacy of care.

Table 1 depicts the four categories of prenatal care utilization as defined by the Kotelchuck index. The index categorizes the month prenatal care began and utilization of care conditional on first visit and gestation. The adequacy of utilization is the ratio of actual to recommended visits expressed as a percentage. Expected visits are based on the ACOG standard for a normal pregnancy adjusted for the timing of the first visit and length of pregnancy. Thus, a woman who initiated prenatal care in the fourth month would have missed three visits, and would be expected to have 12 visits were her pregnancy to last 38 weeks. If she actually obtains only 9 visits, then she is classified as having received 75% of expected utilization. The timing and utilization of care are grouped into a single index of four categories: inadequate, intermediate, adequate and adequate-plus.

The distribution of births by timing and frequency of care is presented in Table 2. From the totals along the bottom row, note that only 56 percent of women receive at least 80 percent of expected visits, and only a slight majority initiate care in the first four months of pregnancy. If we add together the percentages from the four cells in the bottom right quadrant we find that only 32 percent of women receive at least adequate prenatal care as defined by the Kotelchuck index, whereas more than half receive inadequate prenatal care. Prenatal care use among women in the sample compares poorly with more nationally representative datasets. Table 4 shows the distribution of births based on the 1980 National Natality Survey. Over 60 percent of women receive adequate or adequate-plus prenatal care, and only 1.5 percent abstain. The comparison highlights vast differences in prenatal care use between populations and underscores the importance of designing public health policies which address the specific needs of targeted groups rather than national averages.

Race specific birth distributions using the same matrix are shown in Tables 2A-2C. Whites have lower utilization rates of prenatal care than either blacks or

Hispanics. Only 44 percent of whites initiate care by the fourth month, compared with 52 percent of blacks and 56 percent of Hispanics. Nationally, the converse is true. Whites typically initiate care earlier and receive more visits. The anomaly may reflect the nonrandom sample of whites who deliver at public hospitals in New York City. While public hospitals are the primary health care facilities for minorities, only 7 percent of births at the 11 municipal hospitals are to whites. Despite their poor utilization of care, incidence of low birth among whites is less than half the black rate, a consistent finding across a wide range of datasets. Racial disparities in birth weight remain largely unexplained even after controlling for socioeconomic and demographic differences between groups.

Several studies which applied the Kotelchuck index uncovered surprising findings: women who initiated prenatal care earliest and who had greater than expected utilization experienced rates of low birth weight in excess of almost all other women (Korenbrot, Simpson, and Phibbs, 1992; Kotelchuck, 1994b). In addition, rates of low birth weight among women who received less than appropriate care differed relatively little from women who received adequate prenatal care. Rates of low birth weight for all births by timing and utilization of care are shown in Table 4, and by race/ethnicity in Tables 4A-4C. For all births and for each racial/ethnic group, the cells with the highest rates of low birth weight are for women who receive the least care and those who obtain the most. This pattern is similar to Kotelchuck's (1994b) analysis using the 1980 National Natality Survey, and results from Korenbrot, Simpson and Phibbs (1992) using California data, although absolute rates are substantially higher for women in this sample (Table 5).

The association between high utilization of care and poor birth outcomes may reflect adverse selection. Women who anticipate complications may seek care earlier and follow a more intense schedule of visits. Physicians and health researchers have long suspected the role of selection bias in the decision to seek care. However, the Kessner index, the most widely used measure of prenatal care, does not distinguish between women whose care is appropriate for an uncomplicated pregnancy from women whose care exceeds those standards. As a result, the association between adequate prenatal care and birth outcomes as measured by the Kessner index potentially understates the beneficial impact of prenatal care.

We modify the Kotelchuck index by adding a fifth category of care for women who abstain. Aggregating women who receive no prenatal care with those receiving some, albeit insufficient care, inappropriately mixes distinct mothers and their corresponding birth outcomes. Over 90 percent of women in the upper-left cell of Table 4 receive no prenatal care, and their rates of low birth weight are two to three times higher than those in adjacent cells.

Rates of low birth weight shown in Table 4 follow a U-shaped pattern. Women who receive adequate-plus or no prenatal care experience exceptionally high rates of low birth weight, while birth outcomes of women receiving inadequate, intermediate or adequate prenatal care vary little. Women receiving adequate-plus care have followed an ideal prenatal care schedule, and their poor birth outcomes primarily reflect bad health endowments. Unfortunately, government health policies aimed at reducing barriers to care are unlikely to affect these women. In contrast, infants born to women receiving no prenatal care experience elevated rates of low birth weight even in comparison to those who receive inadequate care, suggesting that the marginal benefit of a prenatal visit may be considerable at low levels of care.

The results in Table 4 do not control for underlying differences across groups, thus we cannot determine whether variations in birth outcomes are due to prenatal care use. Adverse selection seems likely among adequate-plus women. Among abstainers, the direction and magnitude of selection bias is uncertain. Lack of prenatal care is correlated with illicit drug use, lower educational attainment, and other characteristics detrimental to the health of the fetus. Thus, poor birth outcomes are not solely a function of insufficient prenatal care. On the other hand, some women abstain from care because they experience a healthy, uneventful pregnancy. In other words, they have better than average health endowments and would experience even worse outcomes if they had less favorable endowments. These potentially contrasting biases may confound the true relationship between prenatal care use and newborn health.

Table 6 presents means of selected outcomes categorized by three indices of prenatal care utilization. There is considerably less variation in birth outcomes across categories in the Kessner index. Newborn costs for infants with late care are roughly $1100 more than those who receive adequate care, and average stays are only two days longer. In comparison, the five category Kotelchuck index (Panel A) reveals considerably larger differences in all measures of newborn health. Infants with no care have hospital stays 5.5 days longer than those who receive adequate care, and incur costs two and a half times higher. There is a U-shaped pattern in birth outcomes in Panel A which is not captured by the Kessner index. The latter index combines women with very different birth outcomes, obscuring substantial variations between groups.

In summary, the Kessner index is a not an appropriate measure of adequacy from either a clinical or empirical standpoint. It aggregates groups of women with dramatically different birth outcomes, masking the true impact of care on newborn health. In contrast, the Kotelchuck index identifies groups most likely to benefit from the governments limited set of policy measures.

IV. Demand for Health

A. Theoretical Framework

Economic models emphasize the importance of parental choices in the production of infant health. Since the focus of the analysis is the role of prenatal care, we simplify the model and use a two-good utility function. We assume parents maximize their joint utility which consists of their own consumption (X) and the health of their expected child (H). Decisions regarding infant health occur in two stages: the mother or parents choose the level of prenatal care while the physician, perhaps acting jointly with the mother, allocates resources given infant health at delivery. Newborn health is a positive function of care, yet subject to diminishing returns.

More formally, parents maximize household utility (U),

$$(1)\quad U = u(X, H)$$

where H is the health of the infant at discharge and X is a composite good that has no impact on H. As an identity, infant health at discharge is equal to the stock of health at birth (S) plus the increase in the stock between delivery and discharge (g).

$$(2)\quad H = S + g$$

Health stock is positively related to birth weight, while g is positively related to length of stay and negatively related to birth weight.

(2') $H = S(B) + g(B,L)$

(3) $H_B = \delta H/\delta B = S_B + g_B > 0$

Let M be prenatal care, p be the price of M and π be the price of L, where p and π include waiting and travel time as well as psychic costs. Finally, let I be income. Maximizing utility subject to resource constraints yields the following first order conditions,

(4) $U_x = \lambda$

(5) $U_H g_L = \lambda\pi$

(6) $U_H B_M (S_B + g_B) = \lambda p$

where λ is the marginal utility of income. Given that g is a positive function of L and negatively related to birth weight, we assume a functional form in (7) using birth weight as a proxy for the stock of health at birth (S).

(7) $g = L^{\alpha 1}B^{-\alpha 2}$

We can then solve for L as a function of π, p, and B, where $\delta L/\delta B < 0$. Parents choose a level of prenatal care and the physician or hospital decision-maker determines length of stay or resource utilization conditional on infant health at delivery. Birth weight is included in the stay equation because it alters the marginal product of (L). For instance, an increase in birth weight lowers the marginal product of postnatal care, thereby shortening stays and reducing resource utilization. In a similar way, we can include prenatal care in the stay equation if it impacts on (g) after controlling for birth weight.

Previous models examining the effectiveness of prenatal services assume care operates solely through birth weight. Although prenatal care provides a variety of medical services, recent evidence suggests that in some cases early identification of pregnancy complications may not prevent prematurity and thus birth weight, but can minimize resulting complications. In other words, early and frequent care may have a greater impact in reducing infant costs and hospital stays than in augmenting birth weight. If one function of care is detection of major complications, then prenatal services may have a larger impact in models which allow care to directly affect infant health.

B. Empirical Framework

The two dependent variables are infant length of stay (L) and costs associated with delivery and postnatal care (C). The costs for infant i can be expressed as a function of birth weight (B), prenatal care use (M) as measured by a modified version of the Kotelchuck index, a vector of inputs such as tobacco and illicit drugs (D), demographic and obstetrical characteristics (X), insurance status (I), parental education (E), and a set of year and hospital dummies (H). Finally, let u represent the random disturbance term.

(8) $C_i = c(B, M, D, X, I, H, E, u)$

This framework presumes the physician acts as a perfect agent for the patient. If the physician or hospital decisionmaker has a different aim such as maximizing newborn health subject to cost constraints, equation (8) would have the same set of righthand-side variables but would also include hospital specific characteristics. We include hospital-specific dummies in empirical specifications which should capture hospital characteristics relevant in the physician's decision-making.

Obtaining consistent estimates of parameters in equation (8) may be difficult if women possess information regarding the health of their pregnancy and use that information in the decision to seek care. Previous work by Harris (1982), Rosenzweig and Schultz (1982, 1983), Grossman and Joyce (1990) and Joyce (1994) suggest that mothers with poor health endowments will seek to offset them by demanding more inputs such as prenatal care. If this occurs, then the disturbance term in the cost equation is correlated with a regressor, biasing OLS estimates. In other words, $Cov(M,u) \neq 0$ and requiring two-stage methodologies to obtain consistent estimates.

Data in Table 4 suggest that adverse selection may be prominent among those who seek the most care, while the direction of selection bias among women who receive inadequate or no prenatal care is more ambiguous. Mothers who abstain from care are more likely to engage in prenatal behaviors detrimental to the health of the fetus. On the other hand, women who receive fewer prenatal services may do so because they experience a healthy, uncomplicated pregnancy. The net result of these contrasting factors is uncertain, although there is weak evidence that adverse selection dominates. In other words, the health endowment effects are greater than adverse effects of maternal behaviors, causing OLS to underestimate the gains to care.

The empirical strategy is to estimate cost and stay equations with and without birth weight. The coefficient on M in equation (9) measures the total effect of prenatal care on costs.

$$(9)\quad C_i = c(M, D, X, I, H, E, u)$$

We anticipate that receipt of inadequate or no prenatal care raises the marginal product of postnatal care and thus is associated with higher infant costs and extended stays. However, I attempt to control for the health endowment in equation (8) by including birth weight as a regressor. In that case, the coefficient on prenatal care measures the direct effect of prenatal services not operating through birth weight.

To estimate care, we use a simple probit when the dependent variable is dichotomous (no care vs. care) and an ordered probit estimated by maximum likelihood for polychotomous measures such as the Kotelchuck index. The modified

Kotelchuck index has five categories of care, j=0 to 4, and is based on clinical recommendations on timing and frequency of care. We use an ordered probit because it captures the ordinal nature of the dependent variable unlike multinomial probit or logit estimation. We predict prenatal care use in the first stage and insert the predicted probabilities in the second stage cost equations (8) and (9), purging the correlation between M and u

The ordered probit reflects a latent variable y*. Let

$$(9) \qquad y^* = \alpha + BX + \epsilon$$

be an unobservable index of prenatal care utilization. We observe

y = No care if $y^* \leq \mu_1$

y = Inadequate care if $\mu_1 \leq y^* \leq \mu_2$

y = Intermediate care if $\mu_2 \leq y^* \leq \mu_3$ ...

where the μs are threshold parameters that must be estimated along with α and B. A limitation of the ordered probit is the inability to identify changes in probabilities from the sign of the coefficients. For instance, an increase in education is expected to decrease the probability of receiving no care, and increase the likelihood of receiving adequate-plus care, the tails of the distribution. However, its effect on the probability of receiving inadequate, intermediate or adequate care cannot be readily inferred, but must be calculated.

We use the natural logarithm of costs and hospital stay in all specifications since their distributions are strongly skewed to the right (Figures 1 and 2). This is typical of medical expenditure data. The majority of infants have hospital stays between 2 and 4 days. Less than 15 percent of newborns remain in the hospital for more than a week and 2.4 percent have stays exceeding 30 days. For now, let C_i represent newborn costs of delivery and postnatal care in the log-linear production function.

$$(10) \quad \text{Ln}\,(C_i) = \tau_1 X_c + \tau_2 M_i + u_i$$

$$(11) \quad D_i = \psi_1 A_i + v_i$$

τ_1 and ψ_1 are 1xk parameter vectors and τ_2 is the coefficient measuring the effect of prenatal care (M) on costs. Let D be a polychotomous indicator that equals 0,1,2,3 or 4 depending on whether a woman receives no care, inadequate, intermediate, adequate, or adequate-plus care, respectively, as measured by a modified version of the Kotelchuck index. Let X and A be vectors of explanatory variables in the cost and prenatal care equations. We suspect the residuals u and v are correlated, and thus single-stage estimates will yield biased coefficients.

One method of obtaining a consistent estimate of τ_2 is a two-stage sample selection correction methodology introduced by Heckman (1976,1979). The procedure rests on the assumption that selection is on a set of unobservables and that the residuals u and v are distributed as bivariate normal. In the first stage, an ordered probit is estimated for the level of care (D_i), using the estimated parameters in equation (11) to construct correction factors (λ_i). In the second stage, we estimate equation (10) on a pooled sample in which the coefficients on the correction factor are assumed to be the same. We also estimate equation (10) separately for each of the five categories with the corresponding correction factor included as a regressor in each equation.

Estimating cost equations for each level of care separates the effects of unobservables from exogenous factors affecting newborn costs. The expected costs for infant i whose mother chooses the jth level of care can be written as:

$$(12) \quad E(C|X,M_j) = X\tau + \delta j + B_\lambda{}^*\lambda_j$$

where δ_j is the coefficient on prenatal care and λ_j the correction factor for the jth level of care. B_λ, the coefficient on λ_j, is the same for all categories of care, j=0,...4. If I repeat the calculation from equation ((12), K=j+1)), I can calculate the expected change in costs associated with different levels of care.

$$(13) \quad E(C|X,M_k) - E(C|X,M_j) = (\delta_k-\delta_j) + B_\lambda{}^*(\lambda_k-\lambda_j)$$

The first term on the right-hand-side of equation (13) is the change in costs from altering the level of care; the second term is the bias in the absence of λ. If the bias term is negative, then ordinary least squares uncorrected for selection underestimates the impact of prenatal care on costs.

C. Independent Variables

The linearity of the model requires that I impose restrictions in order to achieve identification. I assume availability of prenatal care providers, labor market measures and other health area characteristics affect the demand for care, but have no impact on birth weight or infant costs. I include two dichotomous indicators of the availability of prenatal care services. One distinguishes providers that are reimbursed under New York State's Prenatal Care Assistance Program (PCAP). The other designates non-PCAP prenatal care providers. Under New York State's Medicaid expansion initiated in January 1990, designated PCAP providers are compensated for offering a wider range of prenatal services and are authorized to make decisions regarding presumptive eligibility. Any pregnant woman who is eligible for Medicaid and who accesses prenatal care at a PCAP provider is automatically enrolled in PCAP. I expect women who live in health areas served by one or more PCAP providers will receive more comprehensive prenatal services.

The prenatal care equation also includes labor market measures to proxy financial constraints facing low income women. In addition, I include health area measures of homicide rates, drug deaths and syphilis cases to proxy area-specific characteristics. I also include a dichotomous measure of whether the mother worked during pregnancy. Following Hausman (1983), I test the appropriateness of the restrictions.

I impose two additional restrictions. I assume sex of the child is a purely exogenous variable which affects birth weight and costs, but does not alter the demand for prenatal care. Similarly, we exclude method of delivery from the prenatal care equation, but include it in both birth weight and cost equations. Finally, we presume the adverse effects of smoking on fetal growth are captured by birth weight, and thus we exclude cigarette smoking from the cost equation.

There is considerable debate regarding the role of parental education in the infant health production function. In most studies, education is found to have a significantly positive effect on child health status, even after controlling for income (Thomas et al, 1991). Rosenzweig and Schultz (1982, 1983) contend that parental education effects allocative efficiency, improving birth outcomes by altering parental demand for health inputs. Thus, education serves as an instrument in first stage input demand equations and is excluded from the production function. Others have argued that better educated mothers/parents use health inputs more efficiently, incorporating physician advice and health information into prenatal behavior. Furthermore, excluding education may create omitted variable bias, since education is potentially correlated with a range of unobserved or imperfectly measured factors that affect newborn health such as income, nutrition and quality of medical services. We include education in both the prenatal care and cost equations, but will test the sensitivity of parameter estimates to their exclusion.

AFDC eligibility and Medicaid coverage may serve as inducements to give birth and thus may be endogenous (Leibowitz et al, 1986). Grossman and Joyce (1990) found that blacks who chose to give birth rather than abort were more likely to initiate care early and had better birth outcomes on average. Recent work by Currie and Cole (1991) suggests that participation in AFDC is correlated with reductions in birth weight. To test the exogeneity of public insurance, I assume that Medicaid recipients who have experienced a previous live birth are less likely to have enrolled as a result of this pregnancy. Thus, I estimate the cost equations over a subsample of non-first births and compare those estimates to coefficients from a sample of primipara women.

The model assumes smoking and antenatal drug use are exogenous determinants of infant health despite considerable evidence relating inadequate prenatal care to drug and alcohol use. We lack relevant variables to instrument exposures, yet treating them exogenously may be less problematic in this case. First, smoking and drug use are generally preexisting conditions, rather than behaviors brought on by pregnancy. Second, recent evidence suggests the percentage of women who cease smoking during pregnancy is smaller than previously estimated. Nearly 25 percent of women who smoke quit upon learning they are pregnant, yet nearly one-third relapse before childbirth (Chomitz, et al 1995). Moreover, evidence suggests that heavy smokers are much less likely to quit. There is less information regarding cessation of drug use during pregnancy, yet previous research suggests that urine toxicology screens are most likely to identify the heaviest users, and that their quit rates are relatively low. To test the exogeneity of drug use, we will separate the sample by substance abuse, testing the difference in coefficients across subsamples.

Finally, we dichotomize adequacy of prenatal care by timing and frequency of visits. Pohlmeier and Ulrich (1995) argue that the decision to contact a physician is governed by a different stochastic process than frequency decisions, and thus should be modelled separately. The initial visit is patient initiated, whereas subsequent visits are primarily determined by the physician. The distinction is less relevant in this case since so many women do not follow a prescribed schedule of prenatal visits, regardless of when care begins. Many low income women in poorly served health areas do not have a regular physician, and evidence suggests they may underestimate the marginal product of medical care. Omitting the number of visits would exclude important information about the parents motivations and the health of the pregnancy. Consequently, we treat the decision to follow a physician-determined prenatal schedule as an important choice variable in the model.

D. Data

The data consist of New York City vital statistic records for 1990-1992 linked to discharge abstracts provided by the Health and Hospitals Corporation (HHC). The final sample consists of 47,291 mother/infant pairs delivered at one of 11 municipal hospitals in New York City over the three year period. Creation of the study sample involved several steps - matching mothers and infants within the HHC database, and then linking these pairs to DOH vital statistic records. In this section, we briefly describe the data and the matching process, and compare matched and unmatched observations along a limited set of characteristics.

Vital Statistic Records

The New York City birth certificate is one of the most detailed in the country. Besides variables in the U.S. standard certificate, it contains a confidential portion with questions regarding illicit substance abuse, by type of drug, as well as alcohol consumption and smoking levels during pregnancy. The NYC certificate has information on financial coverage, categorized by Medicaid, health maintenance organization (HMO), self-pay and other third party. There is an indicator of enrollment in the Supplemental Nutrition Program for Women, Infant and Children (WIC), prepregnancy weight and weight gain during pregnancy, as well as maternal occupation and work status during pregnancy.

Census Data

Birth certificate data is supplemented with local area information from the 1990 Census. New York City is divided into 352 health areas, each containing approximately 15,000 residents. Area specific variables are used to control for health area characteristics. Race and ethnic specific poverty rates, and labor force participation rates proxy for command over resources. Other area characteristics include homicides per capita, number of deaths due to drug overdoses, and reported cases of syphilis per capita.

Two dichotomous indicators of the availability of prenatal care services will be included. One distinguishes providers that are reimbursed under New York State's Prenatal Care Assistance Program (PCAP). The other identifies non-PCAP prenatal care providers. PCAP providers offer enhanced prenatal services and are authorized to make decisions regarding presumptive eligibility. Nearly 75 percent of Medicaid clients in New York City received care at PCAP facilities in 1992. In general, PCAP clients received more frequent visits and had better birth outcomes after controlling for numerous risk factors. The incidence of low birth weight among PCAP mothers was 7.4 percent versus 11 percent for non-PCAP women. Significantly fewer PCAP clients received first trimester care (44 vs 55 percent), yet more PCAP women received at least 6 prenatal visits (80.5 vs 74.8 percent). The New York State Department of Health estimates that per client PCAP expenditures were 20 to 25 percent above regular Medicaid reimbursement rates (DOH Executive Summary, 1994)

The criteria for becoming a PCAP provider is based on a facility's capacity to provide a range of services and not on area-specific health indicators. Availability measures are often endogenous since they commonly placed in areas with excessively high rates of low birth weight or infant mortality. However, PCAP status is not based on area-specific health measures and thus provides an uncontaminated means of assessing the effectiveness of more comprehensive services. One limitation of this analysis, however, is that despite specific criteria, the range of services offered at PCAP clinics is not homogenous.

Cost Data

Cost data provided by the Health and Hospitals Corporation (HHC) is calculated separately for each mother and infant based on their respective diagnostic related group (DRG). In New York State, there are thirty-nine possible DRG's for neonates. Hospital reimbursement is based on 55 percent of statewide average costs for a particular DRG and 45 percent of hospital specific costs in the base year. Length of stay is simply the number of hospital days associated with delivery. It does not capture the intensity of resource utilization, but is well recorded.

The HHC data also include ICD-9 classifications for substance abuse, based on maternal self-report, chart review, or a positive urine toxicology screen. The substance abuse indicator from HHC will be used to confirm and augment the drug use variable on the birth certificate. This should reduce, although not eliminate, measurement error often associated with the underreporting of drug use on birth certificates. Mean use of heroin and cocaine in our data are similar to other sources. In a sample of over 29,000 women who delivered in California in 1992, 7.8 percent of black women tested positive for cocaine based on urine toxicologies, and 2.5 percent for opiates (Vega et al, 1993). In this sample of high-risk women who delivered at public hospitals, black rates of cocaine and opiate use were 5.9 and 8.2 percent, respectively. Drug use among whites and Hispanics are slightly less than half the black rates.

The financial consequences of prenatal exposure to illicit substances may exceed the indirect effects on costs that operate through birth weight. Infants exposed to illicit drugs not only necessitate longer hospital stays on average, but more intense treatment and utilization of resources. They are more likely to be admitted to neonatal intensive care units (NICU) and have a greater probability of rehospitalization. I include measures of illicit substances as regressors in the cost equation to measure their impact on costs, holding birth weight constant.

Match Rates

The Health and Hospitals Corporation matched birth certificate data with HHC discharge abstracts using a scoring system based on a number of characteristics. Table 7 presents the number of mother/infant pairs that were matched in each of the three years. The discharge data was incomplete prior to August 1991, and thus earlier match rates were relatively low.

Table 8 shows the number of successfully matched records by HHC facility. In 1990, there were two outliers. Coney Island had no matches and Woodhall had few. To gauge relative match rates we divided the number of successfully matched pairs by the total number of deliveries at the facility. The results are presented in Table 9. Third year match rates are high and more consistent, although there was considerable variation in three year rates. Coney Island and Woodhall were considerably below the other facilities.

Many observations were lost in the matching algorithm. I have some information about infants who delivered at HHC facilities who were not matched, in particular, their birth weight and length of stay (LOS). Table 10 shows mean length of stay and birth weight by year for study and non-study infants. Differences in LOS between the two groups are approximately .8 days and this difference is statistically significant. Overall differences in mean birth weight are not statistically significant, nor are differences in 1990, the year of the largest number of unmatched infants. In sum, non-study infants stay longer and weigh less, although the latter difference is less substantial. The most extreme differences are in 1992 in which nonstudy infants are less than two percent of all births delivered within HHC. Although I cannot be certain that unmatched observations did not create selection bias, the effects of inconsistent match rates should be minimized in empirical specifications which include year and hospital-specific dummies.

V. Results

A. Descriptive Statistics

Means and proportions of variables used in the multivariate analyses are presented in Table 11 by race and ethnicity. As noted, whites are more likely to receive inadequate prenatal care than blacks or Hispanics, but have lower risk factors in terms of drug use, education and poverty. Drug use among whites and Hispanics is higher in comparison with national samples, reflecting the women's low socioeconomic status. Black rates are more comparable to national estimates. Over 6 percent of blacks in the sample used cocaine and over 8 percent tested positive or admitted to using heroin during pregnancy. Vital statistic records, based on maternal self-reports, commonly underreport substance abuse. Supplementing birth certificate data with ICD-9 codes reduces underreporting, yet is unlikely to capture the full extent of substance abuse. On the other hand, evidence from previous research suggests that urine toxicology screens are most likely to detect heavy users.

Some additional figures distinguish the composition of the sample. More than 6 out of 10 births are to foreign born women, ranging from 75 percent of Hispanics to 43 percent of blacks. Two-thirds of deliveries are to single mothers; 76 percent of black births are out-of wedlock and 47 percent of whites. Finally, whites are almost twice as likely to be uninsured than either blacks or Hispanics. This anomaly presumably reflects the unrepresentative sample of whites who deliver at public hospitals in New York City. In some cases, insurance status on the birth certificate differs from HHC abstracts. In all specifications, we use the birth certificate measure of insurance status because it more accurately reflects financial coverage during pregnancy. Over 80 percent of women in the sample are covered by Medicaid according to vital statistic records, and nearly 90 percent on HHC abstracts. The discrepancy may reflect the financial incentives of the hospital to register uninsured, Medicaid eligible women at the time of delivery in order to receive compensation for services.

B. Estimates of the Structural Cost Equations

OLS estimates

Table 12 presents OLS estimates of equations (8) and (9), with the natural log of infant costs and hospital length of stay as dependent variables, respectively. The right-hand side contains a full set of control variables including maternal characteristics, prenatal care utilization, drug use by type and insurance status, as well as time and hospital specific dummies. The coefficient on no care in column (1) suggests that abstaining from prenatal care raises costs approximately 16.5 percent relative to adequate care, the omitted category[1]. Similarly, receipt of adequate-plus care raises costs nearly 25 percent. This implies that women who abstain from care

[1]The percentage change in costs (Y) is given by $e^{\beta}-1$ when prenatal care (X) is a dummy variable.

incur infant costs 463 to 700 dollars higher than those who receive adequate care. The results are similar with length of stay as the dependent variable (column 3). Infants born to women who receive no care average 21 percent longer stays, while those receiving adequate-plus care remain in the hospital nearly 18 percent longer than women who get adequate care. The coefficients on intermediate and inadequate care are small in both specifications.

The adverse effects of no care are not surprising, however, large positive coefficients on adequate-plus imply either adverse selection or a negative marginal product of prenatal care. Prenatal care is subject to diminishing returns, yet there is no empirical evidence to suggest that provision of services beyond a recommend number of visits is detrimental to the health of the fetus. More frequent visits provide opportunities for physicians to detect complications, potentially leading to greater use of resources during delivery and postnatal care. However, this presumes the manifestations of those complications would not be identified or treated during the initial hospitalization period if not detected antenatally. A more plausible explanation for the positive coefficient on adequate-plus care is adverse selection - women with a greater likelihood of experiencing complications seek and receive more care, biasing downward the true effects of care.

Results in columns (2) and (4) include birth weight as an exogenous regressor. As expected, the impact of care falls considerably with the inclusion of birth weight since the effects of the health endowment and other unobservables may operate through birth weight. With length of stay as the dependent variable, the coefficients on no care and adequate-plus fall, but remain positive and significant.

Delivery and postnatal costs of Medicaid recipients are over 20 percent higher than for uninsured women, yet average length of stay is 5 percent shorter. This discrepancy does not reflect differences in health status between the two groups since the results are basically unchanged holding birth weight constant. The parameter estimates imply that physicians or hospital decisionmakers alter resource utilization based on a patients insurance status. This result is more surprising in the treatment of newborns. There is some evidence that physicians devote fewer resources to low income patients, especially in treating illness brought on by adverse behaviors such as heavy smoking and drinking. However, I would not expect to see significant differences in the resources devoted to newborns, particularly among not-for-profit public hospitals.

As expected, illicit drug use and smoking raise costs dramatically. Average length of stay for infants whose mothers used heroin during pregnancy is more than three times longer than non-users. Furthermore, controlling for birth weight has little impact on the effects of illicit drug use or sexually transmitted diseases (STD's). This suggests that illicit drug use is not strongly correlated with the health endowment after controlling for other variables.

Adjusted mean differences in newborn costs between adequate-plus and adequate prenatal care are similar to unadjusted mean differences presented in Table 6. The unadjusted mean difference in the natural log of costs between adequate-plus and adequate prenatal care is 0.28. Including a full set of explanatory variables reduces the differential to 0.22. In other words, controlling for observed differences such as parental education, substance abuse, and insurance status explains less than 25 percent of the variation between the two levels of care. In comparison, the regressors explain 55 percent of the observed difference in costs between adequate and no care women. The results are consistent with the hypothesis that high utilization of care is correlated with unobserved factors such as the mother's health endowment and cannot be readily explained by observed covariates.

Large differences in birth outcomes between adequate and adequate-plus care is not captured by the Kessner index. To illustrate the importance of categorizing high risk women, we re-estimate the cost equations by OLS using the Kessner index as a measure of prenatal care. Partial results are presented in Table 13 for all women and by race. The coefficients on prenatal care are small, and in many cases have the wrong sign. Failure to separate women who receive more than the recommended number of visits obscures significant differences, confounding the association between prenatal care and birth outcomes. The results highlight potential measurement error bias from the Kessner index, a serious concern in light of its widespread use in empirical analyses.

To test the sensitivity of parameter estimates using the Kotelchuck index, we modify the basic specification in two ways. First, we exclude exposures - tobacco, heroin, cocaine, and other drugs. Numerous studies that use vital statistic records exclude drug measures on the righthand side since they are based on maternal self-reports and thus underestimate actual use. Second, we exclude parents education from the basic model. Some researchers have argued that parental education affects newborn health by altering the demand for health inputs, and has no impact on reproductive efficiency. The results are shown in Table 14. The coefficient on no care is more than twice as large after excluding exposures. This is not surprising given the disproportionately high rates of substance abuse among no care women. In comparison, the coefficient on adequate-plus care is relatively insensitive to the change. This provides further evidence that outcomes associated with adequate-plus care are primarily a function of health endowments. Excluding education has no significant effect on the prenatal care coefficients, but has some impact on other covariates such as illegitimacy.

To facilitate comparisons with two-stage procedures, we estimate equations (8) and (9) with a dichotomous measure of care. Overall and race-specific results are presented in Table 15. Nearly 13 percent of women in the sample receive no care prior to delivery, an exceptionally high number in comparison to national figures. No prenatal care raises costs and length of stay by 15 and 17 percent, respectively. The positive coefficient on length of stay is reduced, but remains significant, with birth weight as a regressor. The effect on costs, however, is insignificant. OLS estimates reveal the same pattern across race and ethnicities, except the size of the coefficients is significantly larger for blacks. The impact of no care remains significant for blacks holding birth weight constant, but is not statistically significant for whites and

Hispanics.[2]

In sum, OLS results suggest that prenatal care has a modest impact on costs and length of stay, and primarily operates through birth weight. Moving women from no care to inadequate reduces infant costs and length of stay, yet improvements from inadequate to intermediate or adequate care are small and generally insignificant. The large coefficients on adequate-plus care highlight the potential role of unobservables and cast doubt on the consistency of OLS estimates.[3]

Two Stage Estimates

Our basic two-stage model treats prenatal care as endogenous. A Wu-Hausman test rejects the exogeneity of prenatal care, but cannot reject the exogeneity of prenatal care and birth weight as a set[4]. Thus, in two-stage models, we include birth weight and its square as exogenous regressors in the second stage. We use an ordered probit estimated by maximum likelihood for polychotomous dependent variables such as the Kotelchuck index.

---

[2] A Chow test based on OLS estimates uncorrected for selection reveal statistically significant differences in the slope coefficients for blacks and Hispanics. The F-statistic for blacks and Hispanics are 13.45 and 10.53 (df=49,∞), respectively, and 1.64 for whites.

[3]Moulton (1990) notes that regression errors may be correlated within groups when using aggregate explanatory variables on micro units. The assumption of independent errors is usually violated and unadjusted OLS standard errors are biased downward.

[4]Wu-Hausman tests reject the exogeneity of prenatal care ($\chi^2_{1,.95}$=6.65), but cannot reject the exogeneity of prenatal care and birth weight ($\chi^2_{2,.95}$=5.15).

First stage results are consistent with previous estimates (Results not reported). Illicit drug use dramatically increases the likelihood of receiving no prenatal care. Medicaid recipients and those with private insurance are more likely to get care, as are older, better educated and married women. The effects of availability measures and area characteristics are modest, yet statistically different from zero.[5] Table 16 presents second stage results with the natural log of infant costs and hospital length of stay as dependent variables. The coefficients on no care are extremely large and statistically significant at standard levels of confidence over the entire sample, and particularly among blacks. Abstaining from care raises infant costs by 180 percent and extends hospital stays by 209 percent holding birth weight constant. In comparison, no care raises costs and extends length of stay by 2 and 9 percent, respectively, when estimated by OLS. There is little evidence to support such large effects even among a sample of high-risk women. The results vary dramatically by race and ethnicity. Abstaining from care has a large impact on the birth outcomes of blacks and Hispanics, but is only marginally significant among the latter. Prenatal care use has no significant impact on costs or length of stay among whites.

To further explore the role of unobservables, we follow Heckman's two stage procedure. We estimate the first stage in two ways: as a dichotomous measure estimated by a simple probit, and as an ordered probit based on the five levels of care in a modified Kotelchuck index. First stage estimates are used to calculate the

---

[5]An F-test of the eight pure instruments equals $F_{8,\infty,.95} = 5.90$, significantly larger than the critical value $F_{8,\infty,.95} = 1.94$.

appropriate correction factor(s), which is inserted as a separate regressor(s) in the second stage cost equation. Theoretically, the correction factor (lambda) captures the role of unobservables sorting women into different levels of care, consequently, we treat birth weight as exogenous in selection models.

The coefficients on no care are large and strongly significant with a dichotomous measure of care (not reported). No prenatal care raises infant costs by 150 percent and extends length of stay by over 50 percent with birth weight held constant. The coefficients on lambda are negative and significant, which suggests that women who receive no prenatal care have better than average health endowments. This is an important finding. Women who receive no care typically are less educated, are more likely to smoke and use illicit drugs, and act in unmeasured ways which adversely affect infant health. The negative coefficient on lambda suggests that the effects of favorable health endowments outweigh the impact of bad behaviors.

I now estimate prenatal care with an ordered probit for the five levels of care. The second-stage results are shown in Tables 17 and 18, with the natural log of infant costs and length of stay as dependent variables. We repeat OLS results in column (1) to facilitate comparisons. Column (2) includes a stacked correction factor which measures the correlation between the error term in the prenatal care equation and the residual from the cost equation. Column (3) interacts lambda with each level of care. This permits the coefficient on the correction factor to vary by level of care while forcing the coefficients of the other covariates to be the same in each category of care.

The coefficients on prenatal care follow a consistent gradient and are considerably larger than OLS estimates. Relative to adequate prenatal care, receipt of intermediate, inadequate and no care raise infant costs by 8, 20 and 55 percent, respectively. The impact on length of stay follows the same pattern, yet the coefficients are larger in magnitude. Furthermore, after controlling for unobservables, the positive effect of adequate-plus care is either insignificantly different from zero or negative. The results are markedly different from OLS estimates. The marginal effects of intermediate and inadequate care are substantial, and the consequences of abstaining are considerably larger. The positive coefficient on the single correction factor is statistically significant at conventional levels.

Race-specific results of sample-selection models are presented in Tables 17A-17C and 18A-18C. Overall estimates obscure considerable differences across race and ethnicity. In general, the direct effects of prenatal care on length of stay are large and significant for blacks and Hispanics. The impact of care on infant costs is only significant among Hispanics. There is no appreciable effect for whites, regardless of outcome measure. The coefficient on lambda is positive and significant among Hispanics and for blacks with length of stay as the dependent variable. This implies that unobservables leading women to seek non-adequate care raises costs and extends hospital stays.

C. Benefit-Cost Analysis

The majority of women in the sample receive prenatal care at HHC clinics, which are designated PCAP providers. The hospitals are compensated for each prenatal visit according to the Medicaid reimbursement schedule, all inclusive Parts A and B. From April 1990 through March 1991, Medicaid reimbursed PCAP providers $214.27 for an initial prenatal visit, and $113.38 for follow-up visits. Reimbursement rates rose approximately 6 percent per year between April 1990 - April 1992, and 1.6 percent from April 1992 - April 1993. To compute the costs of providing care for each level of the Kotelchuck index, we multiply per visit reimbursement fees by the average number of visits received by women in each category of care. For instance, adequate-plus women receive 12.86 prenatal visits on average. Using average reimbursement rates over the 3-year period, the hospital would receive $226. for an initial visit, and $118. for each of the 11.86 subsequent visits, totaling $1625. Medicaid reimbursement for Non-PCAP providers is $67.50 plus capital reimbursement, totaling $96 per visit. Tables 19 and 20 present overall and race-specific averages of prenatal visits and costs of provision for each level of the Kotelchuck index. The most salient figures are the relatively high costs and extended stays among black infants whose mothers abstained from care. Average infant costs exceed ten thousand dollars, more than three times the cost of adequate care infants. In addition, hospital stays approach 15 days on average, more than double the length of whites and Hispanics.

Coefficients from the cost equations are used to estimate savings from greater levels of prenatal care. Parameter estimates measure the percentage change in costs or stay relative to adequate prenatal care. Therefore, to estimate cost savings we multiply the coefficient by the race-specific average costs or stay for women receiving adequate care. For example, using OLS coefficients in Table 12, no care raises costs 16 percent and extends length of stay 25 percent relative to adequate prenatal care. Infants born to women who receive adequate prenatal care incur expenses totaling $2805. and hospital stays of 4.7 days on average. Thus, receipt of adequate care relative to no prenatal care saves approximately $449 (.16*2805) and 1.03 (.22*4.7) hospitals days. Savings from shorter stays are monetized by multiplying days saved by average per diem costs within each category of care. The average per diem for adequate prenatal care is $598., resulting in savings of $616. Average costs of providing adequate prenatal care for women who abstain is $1373., yielding benefit-cost ratios of .34 and .45 for costs and length of stay, respectively.

Naturally, the parameter estimates are the critical factors in determining the cost-effectiveness of care. The OLS coefficients are not large enough to produce benefit cost ratios greater than one, regardless of the dependent variable or race. However, two-stage parameter estimates for blacks and Hispanics do yield benefits that exceed the costs of providing additional services. The results are summarized in Table 21. Note that the coefficients are from specifications that exclude birth weight, and thus represent the total benefits of care.

VI. Conclusion

Although prenatal care offers a variety of valuable medical services, some evidence suggests it may not provide significant benefits with respect to low birth weight and prematurity. If the main contribution of care is detecting major complications then it will have less effect on birth weight and a relatively larger impact on newborn costs (Shiono et al, 1995). This analysis has sought to measure the the total impact of care and its effect on costs not operating through birth weight. I find that the direct effects of care are negligible when estimated by OLS. However, estimation by instrumental variable techniques and sample selection methodologies yield large, significant effects. The parameter estimates from selection models follow a logical gradient between levels of care. Furthermore, they provide a clearer picture of the relative roles of unobserved behaviors and biological endowments. I find evidence of adverse selection in the decision to seek care among two distinct groups of of black and Hispanic women: those who abstain from care and those who seek the most intense prenatal services. I find that women who abstain from care have better than average health endowments and their endowments have a larger impact on newborn costs than unobserved maternal behaviors thought to adversely affect infant health. In contrast, women who receive the most intense utilization of prenatal services have below-average endowments and experience poor birth outcomes despite intense utilization of prenatal services.

The starting point of this analysis is a new index of prenatal care utilization. I modify the Kotelchuck index by adding a fifth category of care for women who abstain from prenatal care. Unlike the Kessner index, I find the new index separates women with distinct characteristics and vastly different birth outcomes, accentuating the impact of care and identifying women most likely to benefit from government health policies.

I also find that the cost-effectiveness of prenatal care depends on the method of estimation. The costs of providing adequate prenatal care women exceeds benefits when estimated by OLS. However, the Wu-Hausman test strongly rejects the exogeneity of care, and thus OLS estimates are inconsistent. In contrast, the benefits of care exceed the costs of providing additional prenatal services among blacks and Hispanics when estimated by various two-stage methodologies. In addition, I find significant marginal benefits of care. Previous work found the marginal effects of care to be small beyond some threshold level of services (Joyce, 1994). However, in this analysis, I find significant benefits of providing additional care not only to women who abstain, but to those who receive inadequate or intermediate care. The gains to care are large for blacks and Hispanics, yet small and insignificant among whites. This may reflect the atypical subset of whites in the sample rather than racial differences in the effectiveness of care.

Future research should explore the robustness of two-stage estimates with different sets of instruments and over various subsamples of women. The consistency and efficiency of two-stage estimates are a function of their instruments. I used health area characteristics to predict prenatal care use and the correlation between residuals in the cost and care equations. Micro-level instruments may provide better first-stage estimates and thus more efficient second-stage results. Better measures of mothers' prepregnancy health, Medicaid enrollment and exposures to illicit drugs and alcohol would greatly enhance the reliability of the estimates.

Table 1

Categories of Kotelchuck index by timing and utilization of prenatal care

Month Prenatal Care Began	Received Services 0-49%	50-79%	80-109%	110%+
7-9 or none			Inadequate	
5-6				
3-4		Interm.	Adequate	Adeq.+
1-2				

Table 2

Distribution of births by two factors of Kotelchuck prenatal care index for pooled sample of blacks, whites and Hispanics, New York City, 1990-1992 (N=47,291)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	13.7	3.1	3.8	5.1	25.6
5-6	1.5	5.1	6.7	8.1	21.4
3-4	2.7	10.4	14.9	7.3	35.3
1-2	1.9	5.8	6.4	3.6	17.7
Total	19.8	24.4	31.7	24.1	100.0

Table 2A

Distribution of births by two factors of Kotelchuck prenatal care index for sample of whites, New York City, 1990-1992
(N=3,036)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	20.7	4.0	4.7	6.9	36.2
5-6	1.7	4.8	6.9	6.9	20.2
3-4	2.8	9.2	12.8	6.7	31.5
1-2	1.3	3.9	4.7	2.2	12.1
Total	26.4	21.8	29.1	22.7	100.0

Table 2B

Distribution of births by two factors of Kotelchuck prenatal care index for sample of blacks, New York City, 1990-1992
(N=18,817)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	14.3	3.2	3.6	5.2	26.2
5-6	1.6	4.6	6.5	9.5	22.1
3-4	2.7	8.9	14.0	8.2	33.7
1-2	1.9	5.2	6.4	4.4	18.0
Total	20.5	21.8	30.4	27.3	100.0

Table 2C

Distribution of births by two factors of Kotelchuck prenatal care index for sample of Hispanics, New York City, 1990-1992
(N=24,151)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	13.0	3.0	3.7	4.6	24.3
5-6	1.5	5.5	6.8	7.0	20.7
3-4	2.7	11.6	15.6	6.7	36.6
1-2	1.9	6.6	6.6	3.2	18.4
Total	19.2	26.7	32.6	21.5	100.0

Table 3

Distribution of births by two factors of the Kotelchuck index of prenatal care based on 1980 National Natality Survey from Kotelchuck (1994b)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	1.6	0.5	0.9	1.6	4.6
5-6	0.9	2.0	2.1	2.9	7.8
3-4	1.9	9.6	16.3	7.6	34.4
1-2	2.3	12.6	27.0	10.1	52.1
Total	6.7	24.7	46.3	22.2	100.0

Table 4

Rates of low birth weight by two factors of Kotelchuck prenatal care index for pooled sample of blacks, whites and Hispanics, New York City, 1990-1992 (N=47,291)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	19.9	6.2	8.0	7.3	14.0
5-6	9.4	6.5	6.2	12.1	8.7
3-4	9.5	5.3	6.4	17.6	8.6
1-2	9.3	6.8	8.1	20.0	10.2
Total	16.7	6.0	6.9	13.9	10.3

Table 4A

Rates of low birth weight by two factors of Kotelchuck prenatal care index for sample of whites, New York City, 1990-1992
(N=3,036)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	11.3	3.3	1.4	4.8	7.9
5-6	3.9	2.1	2.9	6.3	3.9
3-4	4.8	4.3	3.6	14.7	6.3
1-2	5.3	6.8	6.9	19.4	9.0
Total	9.9	4.1	3.6	9.6	6.7

Table 4B

Rates of low birth weight by two factors of Kotelchuck prenatal care index for sample of blacks, New York City, 1990-1992
(N=18,817)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	29.4	8.1	12.2	8.3	20.3
5-6	12.0	8.9	8.9	14.4	11.5
3-4	13.0	7.2	8.1	21.9	11.6
1-2	12.4	11.0	10.2	22.8	13.8
Total	24.3	8.6	9.2	16.9	14.3

Table 4C

Rates of low birth weight by two factors of Kotelchuck prenatal care index for sample of Hispanics, New York City, 1990-1992 (N=24,151)

	Received Services				
Month Preantal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	13.5	5.0	6.2	6.7	10.1
5-6	8.3	5.3	4.6	10.2	6.9
3-4	7.4	4.3	5.4	13.5	6.7
1-2	7.3	4.5	6.6	16.7	7.7
Total	11.6	4.6	5.6	11.5	7.7

Table 5

Rates of low birth weight by two factors of the Kotelchuck index of prenatal care based on 1980 National Natality Survey from Kotelchuck (1994b)

	Received Services				
Month Prenatal Care Began	**0-49%**	**50-79%**	**80-109%**	**110%+**	**Total**
7-9 or none	18.9	10.4	8.0	7.9	11.9
5-6	7.5	7.7	7.3	13.4	9.7
3-4	9.0	4.6	3.9	15.7	6.9
1-2	9.1	3.3	3.9	14.5	6.1
Total	11.3	4.3	4.1	14.3	6.9

Table 6

Selected means by level of care using the Kotelchuck index with four and five categories and the Kessner Index, from a pooled sample of blacks, whites, and Hispanics in New York City, 1990-1992.

Panel A: Five Category Kotelchuck Index

	Adequate Plus	Adequate	Intermediate	Inadequate	No Care
Mean costs	5839	2805	2604	2984	6793
Mean Ln(costs)	7.72	7.44	7.43	7.47	7.80
Mean LOS	7.7	4.7	4.6	5.3	10.2
Mean Ln(LOS)	1.47	1.25	1.25	1.33	1.70
Mean birth weight	3043	3274	3300	3231	2967

Panel B: Four Category Kotelchuck Index

	Adequate Plus	Adequate	Intermediate	Inadequate
Mean costs	5839	2805	2604	3984
Mean Ln(costs)	7.72	7.44	7.43	7.55
Mean LOS	7.7	4.7	4.6	6.6
Mean Ln(LOS)	1.47	1.25	1.25	1.42
Mean birth weight	3043	3274	3300	3163

Panel C: Kessner Index

	Adequate	Intermediate	Late
Mean costs	2905	3324	3998
Mean Ln(costs)	7.49	7.48	7.57
Mean LOS	4.9	5.3	6.9
Mean Ln(LOS)	1.28	1.30	1.47

Table 7

Total Number and Proportion of Matched Mother/Infant Pairs from a Sample of all Deliveries in the Public Hospital System in New York City, 1990-1992

Year	Total Infants	Matched Mother/Infants	Percent Matched
1990	36,082	23,122	62.8%
1991	33,233	24,619	74.1%
1992	31,466	30,860	98.7%
Total	100,781	78,601	78.0%

Table 8

Matched Mother/Infant Pairs by Year and Public Hospital as Obtained from Dishcharge Abstracts, New York City 1990-1992.

Hospital	**Year**			
	1990	**1991**	**1992**	**Total**
Bellevue	1556	1849	1948	5365
Bronx Municipal	2325	2193	2026	6562
Coney Island	0	1070	2886	3956
Elmhurst	2637	2427	3398	8487
Harlem	1598	2038	2460	6113
Kings County	4312	3825	4084	12259
Lincoln	1762	1554	2090	5437
Metropolitan	3530	3740	3941	11240
North Central Bronx	2053	2003	2591	6664
Queens	3263	3043	3426	9751
Woodhull	131	890	2034	3056
Total	23167	24632	30884	78890

Table 9

Proportion of Matched Mother/Infant Pairs to all Births in the Public Hospital System as Recorded by Birth Certificates by Year and Facility, New York City 1990-1992.

Hospital	Year			
	1990	1991	1992	Total
Bellevue	.81	.93	.96	.90
Bronx Municipal	.84	.88	.93	.88
Coney Island	.00	.35	.96	.42
Elmhurst	.57	.64	.98	.71
Harlem	.64	.85	1.05	.84
Kings County	.89	.85	.99	.90
Lincoln	.57	.66	.97	.71
Metropolitan	.86	.91	.97	.91
North Central Bronx	.67	.74	.97	.78
Queens	.96	.89	.99	.94
Woodhull	.06	.44	.97	.50
Total	.65	.75	.98	.78

Table 10

Comparison of Study and Nonstudy Infants Based on Infant's Length of Stay and Birth Weight from Discharge Abstracts

Characteristic	Year	Study Mean	Nonstudy Mean	T-statistic
Infant LOS	1990-1992	6.01	6.80	-9.64
	1990	6.23	6.73	-4.25
	1991	6.20	6.89	-5.01
	1992	5.70	7.06	-3.03
Birth Weight	1990-1992	3203	3174	0.97
	1990	3248	3221	0.49
	1991	3168	3114	6.29
	1992	3198	3044	5.23

Table 11

Means and Proportions of Selected Variables

Variables	All (N=47,291)	Whites (N=3036)	Blacks (N=18,817)	Hispanics (N=24,151)
Birth outcomes				
Infant costs	3673	2748	4735	2996
Length of stay (LOS)	5.95	5.08	7.22	5.11
Birth weight	3198	3300	3111	3261
Very low BW (500-1499g)	0.02	0.01	0.03	0.01
Moderately low BW (1500-2499g)	0.09	0.06	0.12	0.07
Adequacy of timing index				
Initial prenatal visit, months 1-2	0.18	0.12	0.18	0.18
Initial prenatal visit, months 3-4	0.35	0.32	0.34	0.37
Initial prenatal visit, months 5-6	0.21	0.20	0.22	0.21
Initial prenatal visit, months 7-9 or nocare	0.26	0.36	0.26	0.24
Adequacy of utilization index				
110% or more of expected visits	0.24	0.23	0.27	0.22
80-109% of expected visits	0.32	0.29	0.30	0.33
50-79% of expected visits	0.24	0.22	0.22	0.27
0-49% of expected visits	0.20	0.26	0.20	0.19
Combined Kotelchuck index				
Adequate-plus prenatal care	0.11	0.09	0.13	0.10
Adequate prenatal care	0.21	0.18	0.20	0.22
Intermediate prenatal care	0.16	0.13	0.14	0.18
Inadequate prenatal care	0.39	0.42	0.40	0.38
No prenatal care	0.13	0.19	0.13	0.12
Exposures				

Smoking	0.09	0.09	0.15	0.05
Cocaine	0.03	0.03	0.06	0.02
Heroin	0.05	0.04	0.08	0.03
Other drugs	0.01	0.01	0.01	0.01
Sexually transmited diseases (STD)	0.02	0.02	0.02	0.02
Obstetrical measures				
Prepregnancy weight (log)	4.94	4.94	4.98	4.92
Prepregnancy weight unknown	0.44	0.53	0.36	0.51
Weight gain during pregnancy (log)	3.28	3.29	3.28	3.29
Weight gain unknown	0.46	0.54	0.39	0.53
First birth (1=yes)	0.37	0.44	0.34	0.38
Parity ≥ 4	0.13	0.09	0.18	0.11
WIC	0.52	0.41	0.55	0.52
Sex (1=male)	0.51	0.51	0.51	0.51
Previous fetal loss (1=yes)	0.01	0.01	0.02	0.01
C-section	0.17	0.14	0.16	0.18
Foreign born (1=yes)	0.61	0.53	0.42	0.75
Mother's age	25.6	25.8	25.8	25.4
Mother's age squared	693.6	697.7	704.9	678.8
Mother works during pregnancy	0.10	0.07	0.14	0.08
Mother's schooling				
Mother's educ., 8th grade or less	0.13	0.10	0.05	0.19
Mother's educ., grades 9-11	0.32	0.23	0.35	0.32
Mother's educ., completed high school	0.42	0.48	0.45	0.38
Mother's educ., 1-3 years college	0.09	0.09	0.11	0.08
Mother's educ., completed college or more	0.03	0.06	0.02	0.02
Mother's education unknown	0.02	0.04	0.02	0.01

Father's schooling				
Father's educ., 8th grade or less	0.08	0.05	0.02	0.13
Father's educ., grades 9-11	0.15	0.13	0.10	0.20
Father's educ., completed high school	0.28	0.35	0.24	0.29
Father's educ., 1-3 years college	0.05	0.07	0.05	0.05
Father's educ., completed college or more	0.03	0.06	0.03	0.02
Father's education unknown	0.41	0.34	0.57	0.31
Out-of-wedlock (1=yes)	0.68	0.50	0.77	0.65
Method of Payor				
Medicaid (Birth Certificate/HHC)	0.78/0.89	0.68/0.85	0.80/0.87	0.81/0.91
Uninsured	0.14/0.06	0.23/0.10	0.11/0.06	0.13/0.05
HMO	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01
Other private insurance	0.05/0.05	0.08/0.05	0.05/0.07	0.04/0.04
Payor unknown	0.02/0.00	0.01/0.00	0.03/0.00	0.01/0.00
Local Area Characteristics				
Non-PCAP prenatal clinic in health area (HA)	0.37	0.23	0.44	0.34
PCAP Provider (HA)	0.24	0.14	0.27	0.24
Drug dependent deaths/1000 pop (HA)	0.38	0.23	0.41	0.37
Homicides/1000 pop (HA)	0.88	0.44	1.01	0.84
Syphilis cases/1000 pop (HA)	6.07	3.02	7.95	5.11
Percent poor in census tract (CT)	19.85	16.81	19.40	20.86
Labor force participation rate (CT)	61.77	61.76	61.97	61.49

Table 12

Ordinary least squares estimates of infant costs and hospital length of stay from a pooled sample of blacks, whites, and Hispanics in New York City, 1990-1992 (absolute t-statistics in parentheses).

	Infant Costs	**Infant Costs (With BW)**	**LOS**	**LOS (With BW)**
Variable	(1)	(2)	(3)	(4)
Constant	6.96 (106.56)	11.90 (181.92)	1.08 (19.90)	3.89 (64.17)
Birth weight	---	-0.003 (118.67)	---	-0.002 (71.60)
Birth weight squared	---	0.000 (98.91)	---	0.000 (58.33)
Level of Care				
Adequate Plus	0.22 (18.17)	0.06 (6.35)	0.16 (15.90)	0.07 (7.26)
Adequate[a]	---	---	---	---
Intermediate	-0.03 (2.44)	-0.00 (0.49)	-0.01 (0.62)	0.01 (0.92)
Inadequate	-0.00 (0.47)	-0.00 (0.79)	0.03 (4.27)	0.03 (4.48)
No prenatal care	0.15 (11.19)	0.02 (1.90)	0.19 (17.98)	0.11 (11.49)
Maternal characteristics				
Foreign born	-0.07 (8.65)	-0.03 (4.16)	-0.06 (8.63)	-0.03 (5.18)
Out-of-wedlock	0.01 (0.79)	0.02 (2.20)	0.01 (1.12)	0.01 (1.93)
Mother's age	0.00 (0.79)	0.01 (2.88)	0.00 (1.01)	0.01 (2.45)
Mother's age squared	0.00 (0.36)	-0.00 (1.88)	0.00 (0.58)	-0.00 (0.95)
First birth	0.05 (6.46)	0.04 (5.83)	0.05 (6.97)	0.04 (5.87)

Parity >= 4	0.02 (2.08)	0.02 (1.87)	0.05 (5.99)	0.05 (6.13)
WIC	-0.02 (2.25)	0.01 (1.76)	-0.05 (7.65)	-0.03 (5.40)
C-section	0.37 (41.32)	0.28 (37.77)	0.60 (80.91)	0.55 (80.47)
Previous fetal loss	0.08 (2.69)	-0.00 (0.17)	0.03 (1.08)	-0.02 (0.97)
Insurance Status				
Medicaid	0.19 (17.85)	0.23 (25.84)	-0.05 (5.24)	-0.02 (3.00)
Other third party	-0.05 (2.65)	-0.01 (1.02)	-0.06 (4.03)	-0.04 (2.96)
HMO	-0.09 (2.50)	-0.07 (2.33)	-0.08 (2.65)	-0.06 (2.41)
Finance unknown	0.03 (0.98)	0.04 (1.97)	0.01 (0.32)	0.02 (0.86)
Maternal race/ethnicity				
Blacks	0.08 (6.20)	0.03 (2.71)	0.06 (5.51)	0.03 (2.88)
Hispanics	0.04 (2.86)	0.03 (3.39)	0.02 (2.38)	0.02 (2.52)
Whites[a]	---	---	---	---
Exposures				
Smoking	0.09 (7.00)	0.02 (1.70)	0.10 (9.36)	0.06 (5.60)
Other drugs	0.20 (5.02)	0.10 (3.23)	0.21 (6.38)	0.15 (5.11)
Heroin	1.25 (71.71)	1.14 (78.48)	1.03 (70.70)	0.96 (71.28)
Cocaine	0.48 (23.13)	0.28 (16.35)	0.59 (33.70)	0.47 (29.17)
Sexually Transmitted Diseases (STD)	0.19 (7.71)	0.20 (9.99)	0.20 (9.53)	0.20 (10.76)

Parental Education				
Mother's Educ <= 8 yrs.	0.02 (1.45)	0.03 (2.57)	0.02 (2.42)	0.03 (3.12)
Mother's Educ 9-11 yrs.	0.03 (4.00)	0.03 (4.00)	0.03 (4.77)	0.03 (4.61)
Mother's Educ = 12 yrs.	---	---	---	---
Mother's Educ 13-15 yrs.	0.00 (0.24)	0.00 (0.48)	0.02 (1.55)	0.02 (1.79)
Mother's Educ 16+ yrs.	-0.03 (1.46)	-0.01 (0.41)	-0.05 (2.65)	-0.04 (2.06)
Mother's Educ unknown	0.04 (1.66)	-0.00 (0.14)	-0.02 (1.08)	-0.05 (2.54)
Father's Educ <=8 yrs	0.04 (2.66)	0.03 (2.65)	0.03 (2.37)	0.03 (2.20)
Father's Educ 9-11 yrs.	0.02 (1.52)	0.01 (0.78)	0.00 (0.36)	-0.00 (0.31)
Father's Educ = 12 yrs.	---	---	---	---
Father's Educ 13-15 yrs.	0.02 (1.02)	0.01 (0.63)	0.00 (0.04)	-0.01 (0.41)
Father's Educ 16+ yrs.	0.06 (2.42)	0.05 (2.34)	0.03 (1.74)	0.03 (1.52)
Father's Educ Unknown	0.05 (5.69)	0.02 (2.45)	0.05 (6.52)	0.03 (4.19)
Year & Hospital Dummies				
Yr91	0.25 (30.53)	0.23 (34.13)	-0.01 (1.81)	-0.02 (3.84)
Yr92	0.16 (19.15)	0.15 (21.01)	-0.02 (2.36)	-0.03 (4.01)
H111	0.08 (5.22)	0.07 (5.51)	-0.06 (4.72)	-0.06 (5.56)
H112	-0.07 (4.79)	-0.05 (3.82)	-0.08 (6.36)	-0.06 (5.58)

H121	-0.07 (3.75)	-0.07 (4.49)	0.05 (3.33)	0.05 (3.73)
H131	-0.11 (8.30)	-0.09 (7.89)	-0.11 (9.20)	-0.09 (8.55)
H211	-0.06 (4.03)	0.06 (4.93)	-0.07 (6.35)	-0.07 (6.96)
H231	0.03 (1.52)	0.06 (4.06)	0.11 (8.13)	0.13 (10.37)
H241	-0.27 (20.66)	-0.22 (20.79)	-0.23 (21.37)	-0.21 (20.57)
H242	-0.14 (9.16)	-0.13 (10.79)	-0.13 (9.98)	-0.12 (10.64)
H321	-0.14 (9.66)	-0.10 (8.51)	-0.16 (13.32)	-0.13 (12.35)
H331	-0.29 (12.56)	-0.25 (13.12)	0.04 (2.03)	0.06 (3.56)
Adjusted R-square	.288	0.514	0.352	.454

[a] Reference category

Table 13

Coefficients on Prenatal Care in Basic Cost Equations as Measured by the Kessner Index (Absolute Value of T-statistics in Parentheses)

Level of Care	Infant Costs	Infant Cost (With BW)	LOS	LOS (With BW)
Adequate	---	---	---	---
Intermediate	-0.026 (3.01)	-0.004 (0.57)	-0.003 (0.40)	0.010 (1.50)
Late	-0.025 (2.59)	-0.006 (0.71)	0.045 (5.52)	0.055 (7.38)

Table 14

Prenatal Care Coefficients in Basic Specification and Models That Exclude Exposures and Parental Education

Dependent Variable: Infant Costs

	Adequate-Plus	Adequate	Intermediate	Inadequate	No Care
Basic specification	0.22 (18.17)	---	-0.03 (2.44)	-0.00 (0.47)	0.15 (11.19)
Excludes exposures	0.22 (16.76)	---	-0.02 (1.83)	0.03 (2.75)	0.37 (26.86)
Excludes parental education	0.22 (18.22)	---	-0.03 (2.35)	-0.00 (0.10)	0.16 (12.68)

Dependent Variable: Length of Stay

	Adequate-Plus	Adequate	Intermediate	Inadequate	No Care
Basic specification	0.16 (15.90)	---	-0.01 (0.62)	0.03 (4.27)	0.19 (17.98)
Excludes exposures	0.16 (14.49)	---	-0.00 (0.08)	0.06 (7.44)	0.39 (33.67)
Excludes parental education	0.16 (15.96)	---	-0.00 (0.53)	0.04 (4.70)	0.20 (18.69)

Table 15

OLS Estimates of Cost and Length of Stay Equations by Race/Ethnicity with a Dichotomous Measure of Prenatal Care

	Infant Costs	**Infant Costs (With BW)**	**LOS**	**LOS (With BW)**
No Care - All women	0.14 (12.70)	0.02 (1.86)	0.16 (17.60)	0.09 (10.50)
No Care - Whites	0.13 (3.79)	0.03 (0.91)	0.12 (4.20)	0.06 (2.28)
No Care - Blacks	0.24 (12.18)	0.06 (3.57)	0.27 (16.20)	0.16 (10.49)
No Care - Hispanics	0.06 (4.19)	-0.02 (1.59)	0.08 (7.00)	0.04 (3.39)

[1] Dichotomous measure of prenatal care: (No Care = 1).

Table 16

Two-stage Least Square Estimates of Cost and Length of Stay Equations with a Dichotomous Measure of Prenatal Care by Race and Ethnicity[1]

	Infant Costs	**LOS**
No Care - All women	1.03	1.13
	(3.20)	(3.69)
No Care - Whites	0.05	-0.14
	(0.12)	(0.41)
No Care - Blacks	1.37	1.31
	(2.66)	(2.73)
No Care - Hispanics	0.75	0.66
	(1.62)	(1.59)

[1] Dichotomous measure of prenatal care (No Care = 1)

Table 17

Coefficients on Prenatal Care in Infant Cost Specifications Controlling for Self-selection into Level of Care (Absolute T-statistics in Parentheses)

	Uncorrected for selection*	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.06 (6.35)	0.02 (0.39)	0.01 (0.10)
Adequate	---	---	---
Intermediate	-0.00 (0.49)	0.07 (2.08)	0.13 (3.23)
Inadequate	-0.00 (0.79)	0.18 (2.30)	0.29 (3.09)
No care	0.02 (1.90)	0.44 (2.85)	0.76 (3.70)
Lambda		0.14 (2.43)	---
$Lambda_4$			0.16 (1.92)
$Lambda_3$			0.22 (3.43)
$Lambda_2$			0.18 (2.76)
$Lambda_1$			0.20 (2.85)
$Lambda_0$			0.30 (3.35)
Adj. R^2	.514	.415	.415

* Results from Table 8

Table 17A

Coefficients on Prenatal Care in Infant Cost Specifications Controlling for Self-selection into Level of Care in Sample of Whites, N=3036 (Absolute T-statistics in Parentheses)

	Uncorrected for selection*	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.08 (1.82)	0.17 (1.24)	-0.36 (1.16)
Adequate	---	---	---
Intermediate	-0.01 (0.38)	-0.04 (0.44)	0.16 (1.43)
Inadequate	-0.05 (1.60)	-0.12 (0.60)	0.14 (0.62)
No care	0.00 (0.12)	-0.10 (0.27)	0.62 (1.22)
Lambda		-0.05 (0.36)	---
$Lambda_4$			0.36 (1.56)
$Lambda_3$			0.17 (1.05)
$Lambda_2$			-0.03 (0.21)
$Lambda_1$			0.07 (0.42)
$Lambda_0$			0.31 (1.31)
Adj. R^2	.423	.351	.354

Table 17B

Coefficients on Prenatal Care in Infant Cost Specifications Controlling for Self-selection into Level of Care in Sample of Blacks, N=18,817 (Absolute T-statistics in Parentheses)

	Uncorrected for selection*	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.08 (4.48)	0.03 (0.35)	-0.03 (0.23)
Adequate	---	---	---
Intermediate	-0.01 (0.52)	0.04 (0.74)	0.10 (1.69)
Inadequate	-0.01 (0.49)	0.12 (0.99)	0.28 (2.05)
No care	0.06 (3.31)	0.38 (1.63)	0.88 (2.86)
Lambda		0.10 (1.10)	---
$Lambda_4$			0.18 (1.46)
$Lambda_3$			0.21 (2.06)
$Lambda_2$			0.21 (2.12)
$Lambda_1$			0.23 (2.14)
$Lambda_0$			0.35 (2.62)
Adj. R^2	.557	.464	.464

Table 17C

Coefficients on prenatal care in Infant Cost Specifications Controlling for Self-selection into Level of Care in Sample of Hispanics, N=24,151 (Absolute T-statistics in Parentheses)

	Uncorrected for selection*	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.05 (3.75)	-0.12 (1.30)	-0.04 (0.27)
Adequate	---	---	---
Intermediate	-0.00 (0.19)	0.13 (2.25)	0.17 (2.57)
Inadequate	0.00 (0.13)	0.31 (2.42)	0.38 (2.48)
No care	-0.01 (1.02)	0.60 (2.50)	0.78 (2.48)
Lambda		0.22 (2.43)	---
$Lambda_4$			0.19 (1.56)
$Lambda_3$			0.27 (2.65)
$Lambda_2$			0.22 (2.21)
$Lambda_1$			0.25 (2.27)
$Lambda_0$			0.30 (2.29)
Adj. R^2	.461	.363	.363

Table 18

Coefficients on Prenatal Care in Length of Stay Specifications Controlling for Self-selection into Level of Care (Absolute T-statistics in Parentheses)

	Uncorrected for selection*	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.07 (7.26)	-0.15 (3.02)	-0.07 (0.86)
Adequate	---	---	---
Intermediate	0.01 (0.92)	0.16 (5.01)	0.15 (4.90)
Inadequate	0.03 (4.48)	0.39 (5.40)	0.39 (4.90)
No care	0.11 (11.49)	0.82 (6.01)	0.82 (4.75)
Lambda		0.26 (5.01)	---
$Lambda_4$			0.21 (2.91)
$Lambda_3$			0.25 (4.46)
$Lambda_2$			0.26 (4.74)
$Lambda_1$			0.28 (4.55)
$Lambda_0$			0.26 (3.47)
Adj. R^2	.454	.416	.416

* Results from Table 8

Table 18A

Coefficients on Prenatal Care in Length of Stay Specifications Controlling for Self-selection into Level of Care in Sample of Whites, N=3036 (Absolute T-statistics in Parentheses)

	Uncorrected for selection	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.10 (2.46)	0.08 (0.59)	-0.04 (0.13)
Adequate	---	---	---
Intermediate	0.03 (0.78)	0.05 (0.65)	0.20 (2.02)
Inadequate	0.03 (1.16)	0.10 (0.52)	0.17 (0.85)
No care	0.10 (2.46)	0.23 (0.66)	0.20 (0.44)
Lambda		0.05 (0.35)	---
$Lambda_4$			0.16 (0.74)
$Lambda_3$			0.14 (0.99)
$Lambda_2$			-0.10 (0.67)
$Lambda_1$			0.03 (0.20)
$Lambda_0$			0.04 (0.18)
Adj. R^2	.398	.376	.377

Table 18B

Coefficients on Prenatal Care in Length of Stay Specifications Controlling for Self-selection into Level of Care in Sample of Blacks, N=18,817 (Absolute T-statistics in Parentheses)

	Uncorrected for selection	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.09 (5.61)	-0.15 (1.94)	-0.16 (1.32)
Adequate	---	---	---
Intermediate	0.01 (0.83)	0.16 (3.61)	0.18 (3.65)
Inadequate	0.04 (2.95)	0.40 (3.90)	0.51 (4.46)
No care	0.19 (10.77)	0.95 (4.66)	1.25 (4.81)
Lambda		0.28 (3.58)	---
$Lambda_4$			0.31 (2.90)
$Lambda_3$			0.32 (3.79)
$Lambda_2$			0.36 (4.29)
$Lambda_1$			0.41 (4.47)
$Lambda_0$			0.43 (3.75)
Adj. R^2	.484	.451	.451

Table 18C

Coefficients on Prenatal Care in Length of Stay Specifications Controlling for Self-Selection into Level of Care in Sample of Hispanics, N=24,151 (Absolute T-statistics in Parentheses)

	Uncorrected for selection	Single correction term	Correction term interacted with level of care
	(1)	(2)	(3)
Adequate Plus	0.05 (4.02)	-0.14 (1.79)	-0.04 (0.31)
Adequate	---	---	---
Intermediate	0.00 (0.10)	0.14 (2.66)	0.10 (1.68)
Inadequate	0.03 (3.13)	0.35 (2.96)	0.28 (2.14)
No care	0.05 (4.39)	0.67 (3.07)	0.52 (1.94)
Lambda		0.22 (2.75)	---
$Lambda_4$			0.14 (1.25)
$Lambda_3$			0.17 (1.90)
$Lambda_2$			0.20 (2.34)
$Lambda_1$			0.19 (1.97)
$Lambda_0$			0.16 (1.45)
Adj. R^2	.415	.378	.378

Table 19

Prenatal Visits and Costs of Provision by Level of Care.

All Women	**Average Number of Prenatal Visits**	**Costs of Providing Care**	**Average Infant Costs**	**Average Length of Stay (LOS)**
Adequate-Plus	12.86	1625	5839	7.71
Adequate	10.72	1373	2805	4.69
Intermediate	8.12	1066	2604	4.63
Inadequate	6.52	877	2984	5.31
No Care	0	0	6793	10.24

Table 20

Average Number of Prenatal Visits, Costs of Providing Care, Infant Costs and Length of Stay by Level of Care and by Race

Whites	**Average Number of Prenatal Visits**	**Costs of Providing Care**	**Average Infant Costs**	**Average Length of Stay (LOS)**
Adequate-Plus	13.07	1650	4269	6.17
Adequate	10.92	1397	3202	4.71
Intermediate	8.18	1073	2239	4.48
Inadequate	6.27	848	1857	4.26
No Care	0	0	3925	7.16

Blacks	**Average Number of Prenatal Visits**	**Costs of Providing Care**	**Average Infant Costs**	**Average Length of Stay (LOS)**
Adequate-Plus	12.84	1623	7017	8.91
Adequate	10.60	1359	3248	5.14
Intermediate	8.17	1072	3156	5.28
Inadequate	6.54	880	3493	6.00
No Care	0	0	10317	14.63

Hispanics	**Average Number of Prenatal Visits**	**Costs of Providing Care**	**Average Infant Costs**	**Average Length of Stay (LOS)**
Adequate-Plus	12.85	1624	4644	6.39
Adequate	10.80	1382	2467	4.40
Intermediate	8.09	1063	2341	4.29
Inadequate	6.50	875	2763	4.97
No Care	0	0	4351	7.09

Table 21

Estimated Benefit-cost Ratios by Method of Estimation for Whites, Blacks and Hispanics in New York City, 1990-1992

Panel A: OLS Estimates

Race	Dependent variable	Benefits/ savings	Costs of providing care	Benefit/cost ratio
Whites	Costs	372	1397	0.27
	LOS	556	1397	0.40
Blacks	Costs	964	1359	0.71
	LOS	1180	1359	0.87
Hispanics	Costs	179	1382	0.13
	LOS	260	1382	0.19

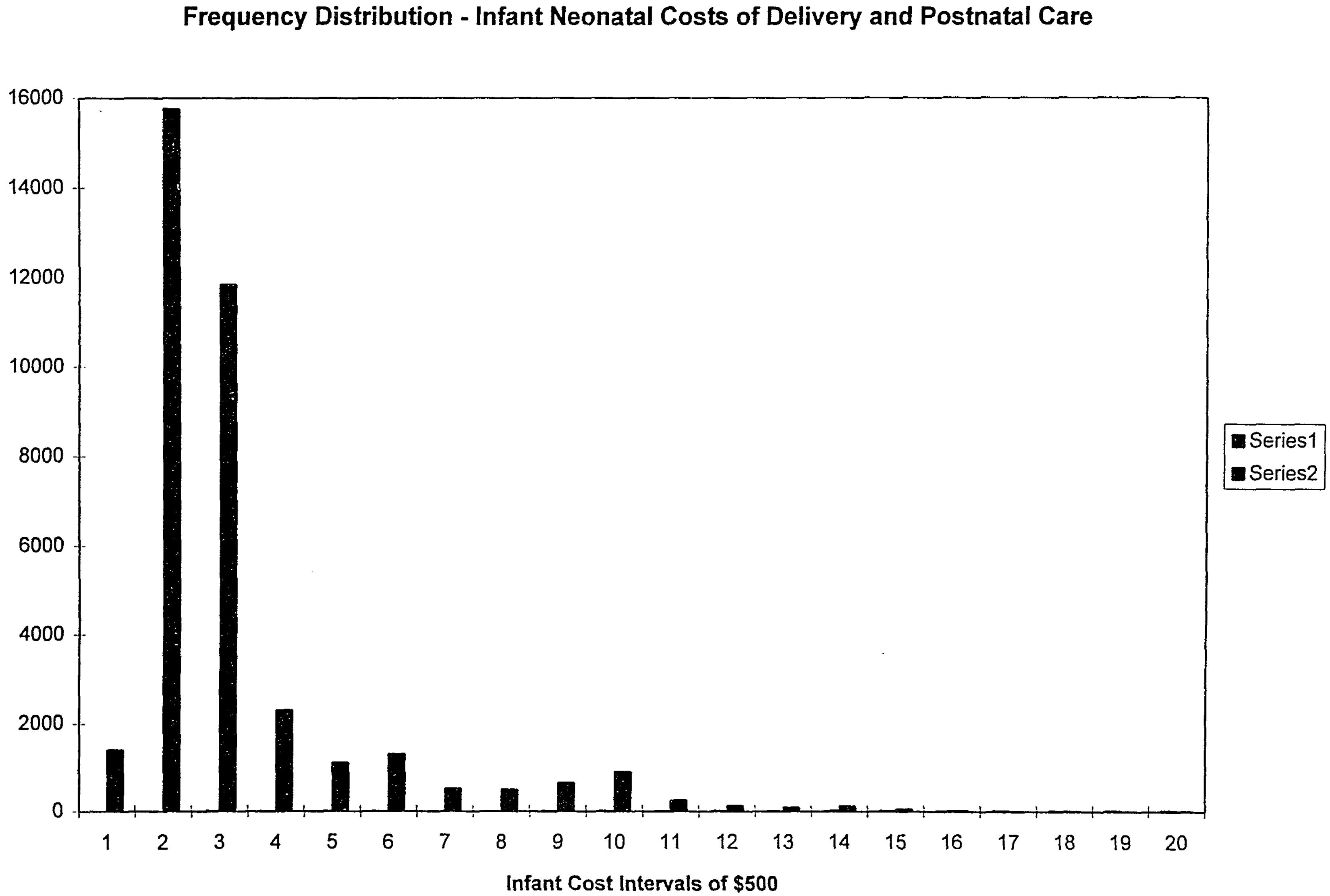
Panel B: 2SLS Estimates

Race	Dependent variable	Benefits/ savings	Costs of providing care	Benefit/cost ratio
Whites	Costs	124	1071	0.12
	LOS	0	1071	0.00
Blacks	Costs	11,415	1070	10.67
	LOS	10,465	1070	9.78
Hispanics	Costs	3149	1065	2.96
	LOS	2525	1065	2.37

Panel C: Sample Selection Estimates

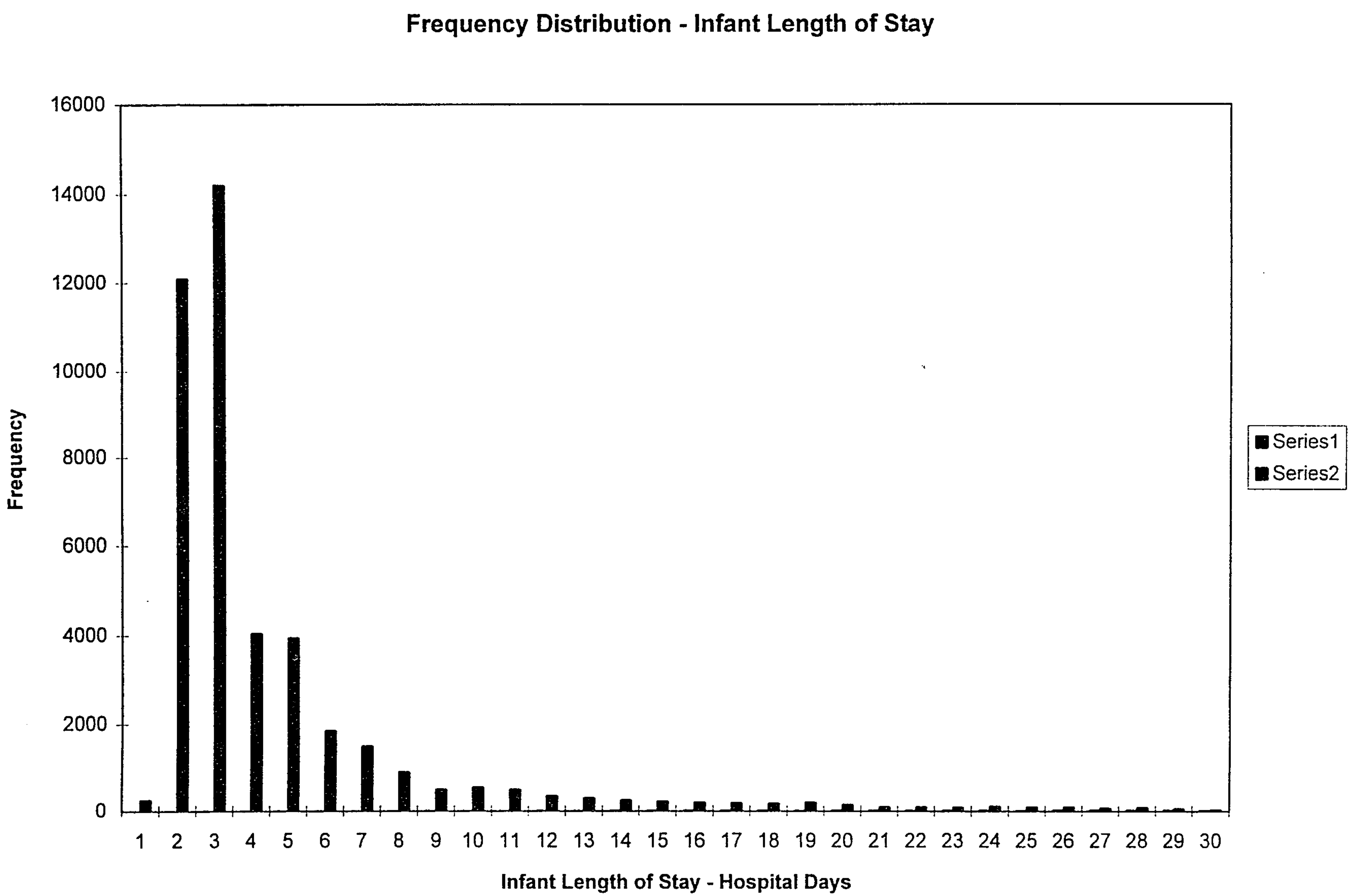
Race	Dependent variable	Benefits/ savings	Costs of providing care	Benefit/cost ratio
Whites	Costs	0	1397	0.00
	LOS	833	1397	0.60
Blacks	Costs	1502	1359	1.10
	LOS	5151	1359	3.79
Hispanics	Costs	4495	1382	3.25
	LOS	2355	1382	1.70

Figure 1



Frequency Distribution - Infant Neonatal Costs of Delivery and Postnatal Care
16000
14000
12000
10000
8000
6000
4000
2000
0
Frequency
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Infant Cost Intervals of $500
Series1
Series2

Figure 2


Frequency Distribution - Infant Length of Stay
Frequency
16000
14000
12000
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Infant Length of Stay - Hospital Days
Series1
Series2

Bibliography

Alexander GR, Korentbrot CC. The Role of Prenatal Care in Preventing Low Birth Weight. The Future of Children - Low Birth Weight. Center for the Future of Children. 1995;5(1):103-120.

Barnow BS, Cain GG, Goldberger AS. 1981. Issues in the Analysis of Selectivity Bias. In Evaluation Studies Review Annual, ed. E. Stromsdorfer and G. Farkas. Beverly Hills: Sage.

Becker GS. A Theory of the Allocation of Time. Economic Journal. 1965;299:493-517.

Bollen KA, Guilkey DK, Mroz TA. Binary Outcomes and Endogenous Explanatory Variables: Tests and Solutions with an Application to the Demand for Contraceptive Use in Tunisia. Demography. 1995;32(1):111-129.

Bound J, Jaeger DA, Baker R. The Cure Can Be Worse Than the Disease: A Cautionary Tale Regarding Instrumental Variables. Journal of American Statistical Association. 1995;90(430):443-450.

Boyle MH, Torrance GW, Sinclair JC, Horwood SP. Economic Evaluation of Neonatal Intensive Care of Very-Low-Birth-Weight Infants. New England Journal of Medicine. 1983;308:1330-1337.

Braveman P, et al. Access to Prenatal Care Following Major Medicaid Eligibility Expansions. JAMA. 1993;269:1285-1289.

Buescher PA et al. Source of Prenatal Care and Infant Birth Weight: The Case of a North Carolina County. Am J Obstet Gynecol. 1987;156:204-210.

Corman H, Joyce T, Grossman M. Birth Outcome Production Function in the United States. Journal of Human Resources. 1987;22(3):339-360.

Cramer JC. Racial and Ethnic Differences in Birthweight: The Role of Income and Financial Assistance. Demography. 1995;32(2):231-247.

Currie J, Cole N. Does Participation in Transfer Programs During Pregnancy Improve Birth Weight? NBER Working Paper. 1991; No. 3832.

Currie J, Gruber J. Saving Babies: The Efficacy and Cost of Recent Expansions of Medicaid Eligibility for Pregnant Women. Unpublished Manuscript. 1993.

Currie J, Gruber J. Health Insurance Eligibility. Utilization of Medical Care, and Child Health. NBER Working Paper. 1995; No. 5052.

Decker S, Gruber J. Public Policy and Infant Outcomes: The Effect of Introducing the Medicaid Program. 1993. Unpublished Manuscript.

Frank RG, Strobino DM, Salkever DS, Jackson CA. Updated Estimates of the Impact of Prenatal Care on Birthweight Outcomes by Race. Journal of Human Resources. 1992;27(4):629-642.

Gortmaker S. The Effects of Prenatal Care Upon the Health of the Newborn. Am J Public Health. 1979;69:653-660.

Grossman M. The Demand for Health: A Theoretical and Empirical Investigation. New York. National Bureau of Economic Research. 1972.

Grossman M, Joyce T. Unobservables, Pregnancy Resolutions, and Birthweight Production Functions in New York City. Journal of Political Economy. 1990;98(5):983-1007.

Gorsky RD, Colby JP. The Cost Effectiveness of Prenatal Care in Reducing Low Birth Weight in New Hampshire. Health Services Research. 1989;24(5):583-597.

Guilkey DK, Popkin BM, Akin JS, Wong EL. Prenatal Care and Pregnancy Outcome in Cebu, Philippines. Journal of Development Economics. 1989;30:241-272.

Guyer B. Medicaid and Prenatal Care. JAMA. 1990;264(17):2264-2265.

Haas JS, Udvarhelyi S, Morris C, Epstein AM. The Effect of Providing Health Coverage to Poor Uninsured Women in Massachusetts. JAMA. 1993;269:87-91.

Hall MH, Chng PK, MacGillivray I. Is Routine Antenatal Care Worth While? The Lancet. 1980;2:78-80.

Harris JE. Prenatal Medical Care and Infant Mortality in Economic Aspects of Health, ed. Victor Fuchs. National Bureau of Economic Research. 1982.

Heckman JJ. Sample Selection Bias as a Specification Error. Econometrica. 1979;47(1):153-161.

Heckman JJ, Macurdy TE. A Simultaneous Equations Linear Probability Model. Canadian Journal of Economics. 1985;18(1):28-37.

Institute of Medicine. Infant Death: An Analysis of Maternal Risk and Health Care.

Contrasts in Health Status, ed. DM Kessner. Washington, DC. National Academy of Sciences. 1973. Volume 1.

Institute of Medicine. 1985. Preventing Low Birth Weight. Washington, DC. National Academy Press.

Joyce T. The Demand for Health Inputs and Their Impact on the Black Neonatal Mortality Rate in the U.S. Soc. Sci. Med. 1987;24(11):911-918.

Joyce T. The Impact of Induced Abortion on Black and White Birth Outcomes in the United States. Demography. 1987;24(2):229-241.

Joyce T, Corman H, Grossman M. A Cost-Effectiveness Analysis of Strategies to Reduce Infant Mortality. Medical Care. 1988;26(4):348-360.

Joyce T. Self-Selection, Prenatal Care and Birthweight Among Blacks, Whites, and Hispanics in New York City. Journal of Human Resources. 1994;29(3):762-794.

Joyce T, Racine A, McCalla S, Wehbeh H. The Impact of Prenatal Exposure to Cocaine on Newborn Costs and Length of Stay. Health Services Research. 1995;30(2):341-358.

Korenbrot CC, Simpson L, Phibbs CS. Prenatal Care Needs Assessment: Comparing Service Use and Outcomes in Fresno, CA. Public Health Reports. 1994;109:66-76.

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

Kotelchuck M. The Adequacy of Prenatal Care Utilization Index: Its Distribution and Association of Low Birthweight. Am J Public Health. 1994;84:1486-1489.

Leibowitz A. The Response of Births to Changes in Health Care Costs. Journal of Human Resources. 1990;25(4):697-711.

Lewit E. The Demand for Prenatal Care and the Production of Healthy Infants. In Research in Human Capital Development. JAI Press. 1983;3:127-181.

Lewit E, Schuurmann Baker L, Corman H, Shiono PH. The Direct Cost of Low Birth Weight. The Future of Children - Low Birth Weight. Center for the Future of Children. 1995;5(1):35-56.

Maddala GS. Limited-Dependent and Qualitative Variables in Econometrics. Cambridge. Cambridge University Press. 1983.

Melnikow J, Alemagno S. Adequacy of Prenatal Care Among Inner-City Women. J Family Pract. 1993;37:575-582.

Mitchell JM, Anderson KH. Expenditures on Services for AIDS Patients Under a Medicaid Home and Community Based Waiver Program: Are Selection Effects Important? Unpublished Manuscript.

Moulton BR. An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units. Review of Economics and Statistics. 1990;72(2):334-338.

Mustard CA, Roos NP. The Relationship of Prenatal Care and Pregnancy Complications to Birthweight in Winnipeg, Canada. Am J Public Health. 1994;84:1450-1457.

New York State Department of Health. Executive Summary: 1992 Prenatal Care Assistance Program (PCAP) Impact Analysis. 1994.

Paneth N. The Problem of Low Birth Weight. The Future of Children - Low Birth Weight. Center for the Future of Children. 1995;5(1):19-34.

Peoples MD, Grimson RC, Daughtry GL. Evaluation of the Effects of the North Carolina Improved Pregnancy Outcome Project: Implications for State-Level Decision-Making. Am J Public Health. 1984;74:549-554.

Piper JM, Ray WA, Griffen MR. Effects of Medicaid Eligibility Expansion on Prenatal Care and Pregnancy Outcomes in Tennessee. JAMA. 1990;264:2219-2223.

Piper JM, Mitchel EF, Ray WA. Presumptive Eligibility for Pregnant Medicaid Enrollees: Its Effects on Prenatal Care and Perinatal Outcome. Am J Public Health. 1994;84:1626-1630.

Pohlmeier W, Ulrich V. An Econometric Model of the Two-Part Decisionmaking Process in the Demand for Health Care. Journal of Human Resources. 1995;30(2):339-361.

Poland ML, Ager JW, Olson JM. Barriers to Receiving Adequate Prenatal Care. Am J Obstet Gynecol. 1987;157:297-303.

Racine AD, Joyce TJ, Grossman M. Effectiveness of Health Care Services for Pregnant Women and Infants. The Future of Children - Low Birth Weight.

Center for the Future of Children. 1992;2(2):40-57.

Racine A, Joyce TJ, Anderson R. The Association Between Prenatal Care and Birth Weight Among Women Exposed to Cocaine in New York City. JAMA. 1993;270:1581-1586.

Reichman NE, Florio MJ. The Effects of Enriched Prenatal Care Services on Medicaid Birth Outcomes in New Jersey. Unpublished Manuscript. 1995.

Rosenzweig MR, Schultz TP. The Behavior of Mothers as Inputs to Child Health: The Determinants of Birth Weight, Gestation, and Rate of Fetal Growth. In Economic Aspects of Health, ed. Victor R. Fuchs. Chicago: University of Chicago Press for the National Bureau of Economic Research. 1982.

Rosenzweig MR, Schultz TP. Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and Their Effects on Birth Weight. Journal of Political Economy. 1983;91(5):723-746.

Rosenzweig MR, Schultz TP. Who Receives Medical Care? Income, Implicit Prices, and the Distribution of medical Services Among Pregnant Women in the United States. Journal of Human Resources. 1991;26(3):473-508.

Schramm WF. WIC Prenatal Participation and its Relationship to Newborn Medicaid Costs in Missouri: A Cost/Benefit Analysis. Am J Public Health. 1985;75(8):851-857.

Schramm WF. Weighing Costs and Benefits of Adequate Prenatal Care for 12,023 Births in Missouri's Medicaid Program, 1988. Public Health Reports. 1992;107(6):647-652.

Schwartz R. What Price Prematurity? Family Planning Perspectives. 1989;21(4):170-174.

Shiono PH et al. Birth Weight Among Women of Different Ethnic Groups. JAMA. 1986;255:48-52.

Shiono PH, Behrman RE. Low Birth Weight: Analysis and Recommendations. The Future of Children - Low Birth Weight. Center for the Future of Children. 1995;5(1):4-18.

Showstack JA, Budetti PP, Minkler D. Factors Associated with Birthweight: An Exploration of the Roles Prenatal Care and Length of Gestation. Am J Public Health. 1984;74:1003-1008.

Sindelar JL. Differential Use of Medical Care by Sex. Journal of Political Economy. 1982;90(5):1003-1019.

Strobino DM. et al. The Impact of the Mississippi Improved Child Health Project on Prenatal Care and Low Birthweight. Am J Public Health. 1986;76:274-278.

Thomas D, Straus J, Henriques MH. How Does Mother's Education Affect Child Health? Journal of Human Resources. 1991;26(2):183-211.

Tucker JM et al. Etiologies of Preterm Birth in an Indigent Population: Is Prevention a Logical Expectation? Obstet Gynecol. 1991;77:343-347.

U.S. Congress, Office of Technology Assessment. Healthy Children: Investing in the Future. OTA-H-345. Washington, DC:GPO. 1988.

Vega WA, Kolody B, Hwang J, Noble A. Prevalence and Magnitude of Perinatal Substance Exposures in California. New England Journal of Medicine. 1993;329:850-854.

Willis R. A New Approach to the Economic Theory of Fertility Behavior. Journal of Political Economy. 1973;81(2):S14-S64.