Selection Bias in Prenatal Care Utilization: An Interdisciplinary Framework and Review of the Literature

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Since there are no randomized trials of standard prenatal care, it is difficult to assess its impact on birth outcomes without controlling for selection processes that can inhibit or promote its use. In this article, we develop a typology of selection processes in prenatal care utilization, identifying four distinct types of selection and their possible biasing effects on estimates of prenatal care efficacy. Second, using an interdisciplinary framework, we review the published studies on birth outcomes that consider selectivity in prenatal care, all of which have been published in the economics literature. The results from these studies suggest that selectivity in the use of care does exist and that the predominant process is one of adverse selection. This implies that analyses failing to control for selection will underestimate the effects of prenatal care. Third, we discuss the public health policy implications of these findings and offer an agenda for future research.

INTRODUCTION

It is well established that infant mortality, low birth weight (< 2,500 grams or 5.5 pounds), and preterm delivery (< 37 completed weeks of gestation) are serious public health problems in the United States. The rate at which infants

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die before reaching their first birthday is higher in the United States than in most other developed nations (Haub and Yanagishita 1991; Howell and Blondell 1994). Significant racial differences in infant mortality have existed for decades, with the Black rate approximately twice the rate for Whites. While infant mortality has declined over the past few decades, the Black/White ratio for neonatal mortality actually has been increasing (Singh and Yu 1995). Similarly, low birth weight and its major antecedent of preterm delivery are more common in the United States than in other developed countries and also exhibit patterns of severe racial disparity (Paneth 1995; National Center for Health Statistics 1994). Low birth weight and conditions associated with prematurity are the leading cause of neonatal mortality (Paneth 1995) and the third leading cause of infant mortality (Singh and Yu 1995), and they contribute significantly to childhood illness and disability (Hack, Klein, and Taylor 1995; McCormick, Gortmaker, and Sobol 1990).

The public policy response to the problems of infant mortality, low birth weight, and preterm delivery has primarily focused on prenatal care. Numerous federal, state, and local policy initiatives and specific programs have been implemented in an attempt to increase opportunities for women—especially those of low socioeconomic status—to start prenatal visits in the first trimester and to continue care throughout their pregnancy (Sardell 1990). During the mid to late 1980s, public policy sought to improve maternal and child health through a series of medicaid eligibility expansions designed to increase the number of women whose obstetric care is covered by the program (Sardell 1990; Schlesinger and Kronebusch 1990). Surprisingly, however, the empirical evidence in support of the policy emphasis on prenatal care is equivocal at best. Decades of research on the association between prenatal care and birth outcomes have not produced strong or consistent support for the contention that early and numerous prenatal care visits reduce the risk of poor reproductive outcomes (Harris 1982; Kramer 1987; Tyson et al. 1980; Alexander and Korenbroot 1995). In addition, evaluations of the medicaid expansions have provided mixed results, with most studies finding that although the expansions did lead to an increase in the use of prenatal care, there was little or no concomitant impact on the incidence of low birth weight or infant death (Schlesinger and Kronebusch 1990; Piper, Ray, and Griffin 1990; Krieger, Connell, and LoGerfo 1992; Piper, Mitchel, and Ray 1994; Currie and Gruber 1994).

The ability to measure the true relationship between prenatal care utilization and reproductive outcomes is critical in advancing the epidemiology of preterm delivery and low birth weight, in assessing the impact of policies and programs, and in developing new policy responses. Unfortunately, several methodological problems continue to plague research on the relationship

between prenatal care and birth outcomes (Peoples-Shep, Kalsbeek, and Siegel 1988; Alexander and Korenbroot 1995; Lantz and Partin 1995). Important among these problems is the issue of selection bias. There are differences in the ways that women seek and receive prenatal care that are not random and are not amenable to observation or measurement. Since there are no data from controlled trials in which women were randomly assigned to varying levels of prenatal care, it is difficult to assess the impact of prenatal care on outcomes without controlling for the selection processes that can either inhibit or promote its use. Without an assessment of the magnitude and type of selection processes that are in operation, estimates of the potential impact of prenatal care use on population birth outcomes may be biased.

Researchers have responded to the knotty issue of selection bias in prenatal care utilization in a variety of ways. A large portion of the published work on birth weight, preterm delivery, and infant mortality that considers prenatal care as an independent variable simply ignores selection issues. Some researchers acknowledge the possible existence of selection processes in the use of prenatal care services but conclude that the effects are likely to be minimal or can be controlled for (Terris and Glaser 1974; Murray and Bernfield 1988; Cramer 1995). Others view selection bias as an issue that is important in reproductive health research yet intractable in the absence of clinical trial data (Malloy, Kao, and Lee 1992; Kramer 1987; Mustard and Roos 1994; Alexander and Korenbroot 1995). For example, Eisner et al. (1979) emphasized that selection processes may have influenced the use of prenatal care and concluded that their research "showed that lack of prenatal care is an indicator of risk but does not allow conclusions about the effect of providing earlier care" (p. 892). Despite the authors' caveat, this study and others like it have been cited in numerous research and review articles as evidence of the importance of including prenatal care in policies and programs attempting to reduce the incidence of low birth weight.

A number of researchers have attempted to estimate the impact of prenatal care on outcomes, primarily birth weight, while taking selection processes in the use of prenatal care into account. These authors use econometric techniques to control for selection bias, which can result in endogenous explanatory variables, that is, correlation between certain explanatory variables and the error term (Heckman 1979; Maddala 1983). Without exception, this work has been conducted by economists, and the results have appeared in the economics literature rather than in the clinical medicine, public health, or health policy literature. As a result, many researchers and policy makers who are interested in the relationship between prenatal care and birth outcomes may be unaware of the majority of published studies on this topic that address the issue of selectivity.

We believe that the issue of selection processes in prenatal care utilization is critical in research on the determinants of pregnancy and birth outcomes, especially research aiming to inform health policy. Thus the objectives of this review are (1) to provide a thorough description of the issue of selectivity in prenatal care use, including a typology of four distinct types of selection; (2) to offer an interdisciplinary framework that is useful in elucidating the approach taken by the majority of economic studies of prenatal care demand and birth weight production; (3) to make the technical methods and important findings of these economic studies available to a broader audience; and (4) to propose a research agenda for further study in this area. The overall goal of this endeavor is to improve research on the determinants of birth outcomes and to further the development of public health policies aimed at improving population reproductive outcomes.

NEW CONTRIBUTION

The primary contribution of this article is that it provides an in-depth discussion and review of an issue that is of critical importance to public policy in regard to infant health yet has received surprisingly little attention in the literature to date. We begin our review by conceptualizing the issue of selectivity, describing several selection processes that are hypothesized to influence both the use of prenatal care and pregnancy outcomes. The currently published articles or studies that discuss selectivity in prenatal care use refer to favorable and/or adverse selection only. In contrast, we offer a unique typology of four different selection processes. Next, we recast the economic framework of "prenatal care demand" and "birth weight production" into a health services research framework of structure, process, and outcome that should be useful to a wide and diverse audience. In addition, we use this framework to review the methodologies and major findings of economic studies of the determinants of birth outcomes, with a primary focus on birth weight. To date, there is no published review of this literature, which—as mentioned above—appears primarily in economics journals (which are not indexed by Medline). Thus our work here serves to make this body of work available and understandable to a broader audience. Finally, we assess the strengths and limitations of the current research, make suggestions for future research in this area, and discuss the relevance of this important issue for public health policy.

A TYPOLOGY OF SELECTION PROCESSES

The issue of selection bias is omnipresent in health services research, especially studies regarding the impact of a health service on a particular

outcome. It is likely that those people who use a specific type of health service differ from the people who do not in ways that are unobservable and difficult to measure yet also are related to the outcome under study. These differences can be in the form of knowledge, attitudes, and perceptions regarding health, risk behaviors and health practices, health endowment, or health status. These differences can be subtle, and our datasets often do not provide the information needed for adequate analytical control. Thus, in the absence of a clinical trial with random assignment, it is quite likely that selection processes are at work. The critical question becomes whether or not the selection process is biasing the observed association between the health service and the outcome under study.

We created a typology of selection processes in prenatal care utilization by identifying four distinct types of selection processes that are plausible from an empirical and theoretical viewpoint (see Table 1). These four selection processes are labeled as favorable, adverse, estrangement, and confidence selection. These processes and their possible biasing effects are discussed below.

Favorable selection occurs when women at low risk for a poor birth outcome are also high users of prenatal care. Women who receive early and continuous prenatal care may be predisposed to having healthy outcomes because of unmeasured characteristics or behaviors that are related both to the propensity to seek prenatal care and to positive birth outcomes. As such, these positive outcomes are a function of both the things that lead women to be high users of prenatal care and of the care itself. This selection process, therefore, has the potential to bias estimates of the effect of prenatal care on birth outcomes upward, that is, it leads to an overestimation of the impact of prenatal care.

There is evidence that the types of women who are most likely to start prenatal care early and receive an adequate number of visits are also the same types of women who are at low risk for a poor outcome, that is, nonsmoking, married women with higher levels of income and education (Greenberg 1983). Researchers often acknowledge that unmeasured variables for which there are no controls (such as better fetal health endowments or the propensity to engage in health-promoting behaviors) may be associated with both higher levels of care and more favorable outcomes. However, few empirical studies have focused on favorable selection processes.

Adverse selection occurs when women at high risk for a poor birth outcome are also high users of prenatal care. Women who receive early and intensive prenatal care may be doing so because they anticipate that they are at higher risk for a problem pregnancy or a poor birth outcome. These women may realize that they or their fetuses are at a health disadvantage because of an

TABLE 1: Typology of Selection Processes in the Use of Prenatal Care

Selection Process	*Risk for Poor Birth Outcome*	*Prenatal Care Utilization*	*Resulting Bias in Estimates of the Effect of Prenatal Care*
Favorable selection	Low	High	Overestimation
Adverse selection	High	High	Underestimation
Estrangement selection	High	Low	Overestimation
Confidence selection	Low	Low	Underestimation

existing medical condition, prior experience, family history, or recognition of risk behaviors. There is empirical evidence that the women who are the most intense users of prenatal care, that is, those who have the greatest number of visits, are significantly more likely to have a premature or low birth weight infant (Kotelchuck 1994; Alexander and Cornely 1987). In this case, poor birth outcomes are a function of the things that lead women to be high users of prenatal care rather than a result of the increased use of care. Therefore, this selection process has the potential to bias estimates of the effect of prenatal care on birth weight downward, that is, it leads to an underestimation of the impact of prenatal care. Depending upon the degree to which adverse selection exists, a more intense public health policy focus on prenatal care may be warranted. The economics literature on selection bias in prenatal care demand has focused almost exclusively on adverse selection, as discussed in detail below.

Estrangement selection yields a similar empirical result to favorable selection yet ostensibly involves a different group of women. This type of selection process implies that some of the women at high risk for a poor birth outcome are among the lowest users of prenatal care, including those few women who receive no prenatal care at all. We view these women as being estranged from the health care system and also as being estranged from mainstream society in terms of their behaviors and lifestyle, for example, women who suffer from substance abuse, prostitutes, homeless women, young runaways, and so on. In this case, it may not be the effect of having little or no prenatal care that is causing poor outcomes. Rather, it may be the unmeasured behavioral traits, characteristics, socioeconomic conditions, and other risk factors that are directly related to both low or no prenatal care use and a higher incidence of negative outcomes.

The empirical result of estrangement selection is similar to that of favorable selection; from a population perspective, estrangement selection leaves lower-risk women using prenatal care at a relatively higher rate. Thus this selection

process also has the potential to bias estimates of the effect of prenatal care on birth outcomes upward, that is, it leads to overestimation of the impact of prenatal care. If this type of selection process does exist, then programs that focus on getting women into prenatal care rather than on the social causes of their poor outcomes may not have a strong effect on birth outcomes.

Confidence selection suggests that some women at low risk for adverse outcomes are also more likely to receive little or no prenatal care. It is possible that some women who start prenatal care late or receive no care at all are predisposed to having a healthy outcome. These women are confident that they are at extremely low risk for a variety of reasons. The most likely reason is that they have experienced a previous healthy birth, are knowledgeable about the content of prenatal care, and do not see any benefit in seeking standard prenatal care services early or continually throughout the current pregnancy. They may also have favorable predictions of their fetus's health endowment. In this type of selection, women perceive themselves as being at low risk for a poor outcome and are confident they can achieve a healthy outcome without prenatal care.

Confidence selection is observationally equivalent to adverse selection because it implies that higher-risk women in the population use prenatal care at a relatively higher rate. Therefore, this process would also bias estimates of the effectiveness of prenatal care downward, that is, produce an underestimation of the impact of prenatal care. At the present time, there is no empirical evidence regarding confidence selection, but it is plausible for some women to be both at low risk for a poor birth outcome and low users of prenatal care.

Our typology of selection processes describes selectivity in terms of prenatal care and outcomes for live births. Of course, there also are selection processes at work in terms of who actually proceeds from pregnancy to a live birth. Events such as spontaneous abortions or fetal demise remove women from the population of those who have live births. In addition, women who have induced abortions are likely different from those who do not in terms of endowments, characteristics, and traits that are potentially related to both birth outcomes and patterns of health services utilization (Joyce and Grossman 1990).

Unfortunately, beyond the articles discussed in the review and the more descriptive work mentioned earlier, there is little empirical evidence regarding the extent to which each of the prenatal care selection processes described above actually occurs. It is plausible that all of these selection processes are in operation, with the effects of one type diminishing or counterbalancing the effects of another—a complex and unwieldy state of affairs. It is also plausible that if more than one type of selection is in operation, the effects of favorable or adverse selection processes dominate the estrangement and

confidence selection processes. The true relationship between prenatal care and birth outcomes will remain unknown in the absence of continued and improved research in this area.

AN INTERDISCIPLINARY FRAMEWORK FOR SELECTION BIAS IN PRENATAL CARE UTILIZATION

The economic models that have been developed to examine the relationship between prenatal care utilization and birth weight have been based on models of household economics and human capital (see Becker and Lewis 1974; Grossman 1972). In summary, this type of model suggests that certain factors influence maternal behaviors, which, in turn, directly affect fetal development. The separation of the process of fetal development from the determinants of maternal behavior allows for the use of econometric techniques that can control for selection bias if it exists.

In this section, we use an interdisciplinary framework of "structure, process and outcome" to elucidate the economic approach that has been used in virtually all of the published literature on selection bias in prenatal care utilization (see Figure 1). Using this framework, the *outcome* under study is the weight of an infant at birth. The biological *process* of fetal development and gestational age at delivery affects this outcome, and this process itself is affected by the health endowment of the fetus and by maternal health and behaviors. Variables that affect this process (such as maternal smoking, age, and prenatal care, and so forth) have a direct impact on birth weight outcomes. In addition, underlying a pregnant woman's behavior and choices are features of her environment or *structure*. These structure variables (such as health insurance, socioeconomic status, and medical care availability) have an effect on birth weight outcomes, but only indirectly through their impact on more proximate determinants of birth weight, or the process variables. Thus the links between structure and outcome are indirect.

Many published studies on the determinants of birth weight mix structure and process variables by considering them simultaneously in the same regression equation (Murray and Bernfield 1988; Kallan 1993; Cramer 1995). However, when the structure and process variables are not clearly separated, the estimation of such models cannot control for the effects of selection. In contrast, several studies published in the economics literature have separated these two types of variables in an attempt to control for selectivity (these studies are reviewed in detail below). In all of these studies, the process by which a mother's behavior and her use of medical care influences birth weight is referred to as the "birth weight production function." Prenatal care utilization and maternal behaviors such as smoking or nutrition are considered

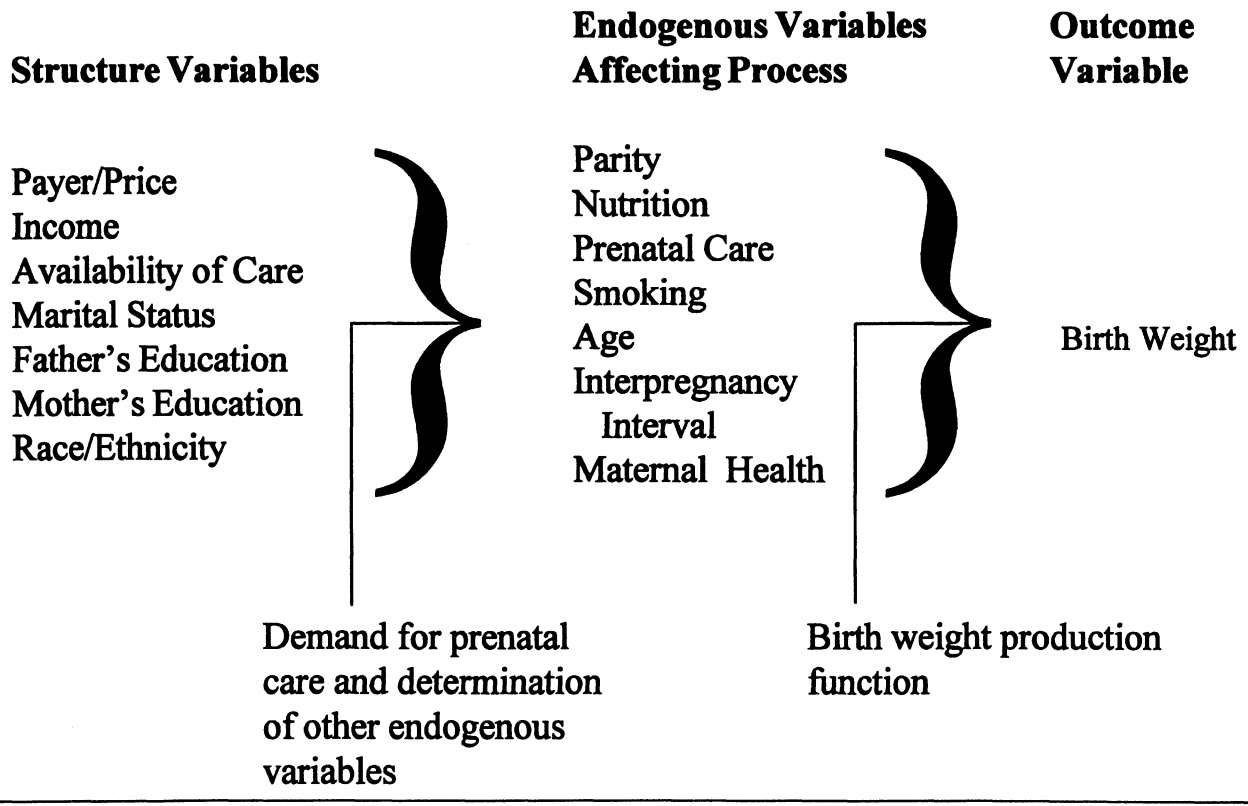

FIGURE 1 Structure and Process in Birth Weight Outcome

"inputs" to this production function or process. The terminology of "producing" a child of a certain weight may not appeal to some people, as it likens pregnancy outcomes to the factory production of goods. The basic idea, however, is not foreign to most health services researchers: A combination of medical care use and other behaviors can have a direct effect on a health outcome (e.g., birth weight). This concept is important because it forces researchers to consider the variables that directly affect the process.

Structure variables that indirectly influence birth weight outcomes include those preferences, resources, and costs that have an impact on the more proximate determinants or processes under study, including the use of prenatal care. In the published literature on selection bias, special attention was given to the determinants of prenatal care use, termed the "prenatal care demand function." Examples of structure variables considered in models of the demand for prenatal care include maternal educational attainment, marital status, race, income, health insurance, and paternal factors. Additional variables related to prenatal care access were also considered, such as the number of providers in a geographic area and price of available care. These factors may have an impact on the process variables mentioned above, but they do not have a direct impact on birth weight. For example, income may have an impact on a pregnant woman's nutritional status and her use of prenatal care, but it does not have a direct effect on the biological process of intrauterine growth retardation or gestational duration.

The studies we review typically include only the variables affecting the process in the regression with birth weight as the dependent variable; this is because the structure variables affect birth weight only indirectly. If selectivity is occurring, the variables that affect the process may be correlated with the unobservable determinants of birth weight. This would lead to biased estimates of the effects of these variables on birth weight. Estimating a system of equations in which the structure variables influence those variables affecting the process, and, in turn, the process variables directly affect the birth weight outcome, may produce unbiased estimates of the effects of prenatal care on birth weight.

Two approaches to controlling for selection bias in the use of prenatal care can be found in the published literature. In the first case, a single birth weight equation is estimated. The actual amount of prenatal care is not used as an explanatory variable. Instead, an estimate of the amount of care used, based on variables that are not likely to be correlated with unobservable determinants of birth weight, is used (i.e., an instrumental variables approach) (Kennedy 1992, pp. 134-137, 143-145, 148-149).

In the second case, separate regressions are run for groups of women with different categorical levels of prenatal care. Information from a regression for

estimating the probability of a woman receiving each level of prenatal care is used to obtain unbiased estimates of coefficients for each set of variables for each group. Similar maternal characteristics can be used with each set of regression results to demonstrate how birth weight depends on the categorical level of prenatal care received.

In this section, we have attempted to provide an overview of the general analytical approach taken by researchers in the published literature that attempts to control for selectivity processes in the use of prenatal care, recasting this economic approach using a more general, interdisciplinary framework. Below we provide reviews of the major published studies in this area to date, including summaries of the research designs and major findings.

REVIEW OF LITERATURE ON PRENATAL CARE AND BIRTH OUTCOMES CONTROLLING FOR SELECTION

A. SELECTIVITY AND ESTIMATES OF BIRTH WEIGHT

Rosenzweig and Schultz (1983) were the first researchers to publish an empirical description of the effects of selection processes in the use of prenatal care on estimates of birth weight. Using nationally representative data from the 1967, 1968, and 1969 National Natality Surveys, they sought to demonstrate that estimates of the impact of prenatal care on birth weight depend upon the ability to control for the effects of the health endowment on the demand for prenatal care.

The dependent variables used by Rosenzweig and Schultz included both birth weight (in grams) and birth weight adjusted for the gestational age. The measure of prenatal care used was a measure of delay, that is, the number of months between conception and the first prenatal care visit. Prenatal care, maternal smoking behavior, maternal age, and the number of current live births were treated as input variables that may be related to the health endowment, that is, variables that are endogenous or related to some of the unobservable determinants of birth weight. Rosenzweig and Schultz followed a two-step analytical process in which these endogenous variables were first predicted, and then the predicted values were used in estimating birth weight.

Rosenzweig and Schultz's findings demonstrate the need to control for selection bias in prenatal care utilization. Ordinary least squares (OLS) estimates suggested that an increase in the time between conception and the first prenatal care visit did not have a significant effect on birth weight. However, when controlling for the correlation between the health endowment and input variables, the authors found that an increase in the delay in care initiation had

a negative and significant effect on birth weight. This study produced evidence of downward selection bias, which Rosenzweig and Schultz interpreted as evidence of adverse selection, that is, that unobservable knowledge about health endowment led some high-risk women to seek earlier care. Without controlling for this selection process in the use of prenatal care, estimates of the impact of prenatal care erroneously suggest that early care initiation does not contribute to improvements in birth weight. Another interesting finding of this study was that the early initiation of prenatal care did not have beneficial effects in two-stage analyses in which the dependent variable was birth weight standardized for gestational age. This finding suggests that early prenatal care has the effect of lengthening gestation rather than increasing fetal growth within specific gestational periods.

Rosenzweig and Schultz's findings suggested that a delay in the initiation of prenatal care from early in the first trimester to early in the second trimester led to a 9.1% reduction in birth weight. See Table 2 for summary information on the empirical results from this study and the other articles summarized in this review.

Rosenzweig and Schultz (1988) subsequently reestimated these models with data from the 1980 National Natality Survey and found similar evidence of adverse selection. The stability of most of the coefficients in the two-stage least squares regressions led them to believe that they had identified some fundamental parameters of the birth weight production process. Given their combined results, the authors concluded that the choice to obtain early prenatal care under adverse conditions played a role in explaining why a delay in care initiation did not have a direct association with birth weight but did have negative and statistically significant consequences in two-stage least squares estimates. Again, the empirical results (Table 2) suggest that a delay in the initiation of care from early in the first trimester to early in the second trimester reduced birth weight by a small yet significant amount (8.2%).

Warner (1995) built on the work of Rosenzweig and Schultz, expanding the inquiry by using a model in which the total number of prenatal care visits was considered along with the timing of care initiation. Increasing the number of visits was hypothesized to have a positive and independent effect on birth weight. Warner hypothesized that an interaction between these two variables could also have an effect; that is, the effect of an additional prenatal visit on birth weight could vary as the timing of care initiation varied, and the effect of an increase in care delay could vary as the number of visits varied. An interaction term was used to assess whether women who initiate care early can afford to have fewer visits and still have the same birth outcome (early care initiation and a large number of visits are *substitutes* for each other), or if the positive effects of early care initiation can be increased with numerous

visits thereafter (the two are *complements*). Warner used the ratio of the total number of prenatal care visits to the number of days from the first day of the woman's last menstrual period to her first prenatal visit as the interaction term.

The sample for this analysis was singleton births to non-Hispanic mothers of African descent 21-35 years of age in New York City, 1980-1990 ($N = 95,332$). Data were obtained from vital records, a New York City Department of Health survey, and several state-level sources of data. Following Rosenzweig and Schultz, Warner treated the number of visits, the timing of care initiation, and the ratio as endogenous variables, that is, variables that may be affected by information the woman knows but that is part of the error term from the perspective of the researcher. The use of actual rather than predicted values would have led to biased estimates of the effects of earlier care initiation and more visits. Thus, in an attempt to control for selection processes, Warner ran regressions to obtain predicted values of each of the prenatal care variables, and then used these values along with additional process variables in a regression with birth weight in grams as the dependent variable. Variables included in the prenatal care demand equation but not in the birth weight equation were father's education, maternal age, and area health variables. Drug, alcohol, and smoking behavior were included in the birth weight equation but not in the prenatal care equations.

Warner's results (Table 2) showed that the number of visits was not a significant determinant of birth weight, but that decreasing the length of time between conception and the first visit had small yet significant direct effects on birth weight. For example, Warner's empirical results suggested that a 3-month delay in care initiation had a direct negative impact on birth weight on the order of 98 grams (3.5 ounces). The interaction term was negative but insignificant, making the total effect of a delay in care initiation less than the direct effect described above. Warner's results can be interpreted as implying that helping women to obtain early prenatal care is more important than increasing the number of visits they receive in terms of lowering the incidence of low birth weight. However, the results should not be generalized beyond the population studied (urban African American women ages 21-35).

Frank et al. (1992) took a different approach in addressing the issue of selection bias in the use of prenatal care, using county-level rather than individual-level data. Data from 1975 to 1984 on U.S. counties with 10,000 or more Whites or 5,000 or more Blacks were analyzed. Two obvious limitations to using county data are that county-level indicators will not reflect the characteristics of many individuals within the county and that the average health endowment or the average value for other unobservable factors will not vary as much by county as by individual. Frank et al., however, suggested

TABLE 2: Summary of Results From Econometric Studies of the Effects of Prenatal Care on Birth Outcomes in U.S. Populations

Study	*Prenatal Care Measure*	*Outcome Measure*	*OLS Results**	*Controlling for Selection**
Rosenzweig and Schultz (1983)	Log of delay in months	Log of birth weight in grams	–0.00178 (0.41)	–0.0682 (2.84)
	Log of delay in months	Log of gestation-adjusted birth weight in grams		0.000973–0.00216 (0.28)(0.11)
Rosenzweig and Schultz (1988)	Log of delay in months	Log of birth weight in grams	–0.00160 (0.60)	–0.0617 (3.07)
Warner (1995)	Delay in days	Birth weight in grams	—[†]	–1.05 (1.86)
	Number of visits			3.94 (0.42)
	Number of visits divided by delay in days			–361.19 (0.56)
Joyce (1994)	Kessner Index (numbers shown reflect the increase in grams of moving the subpopulation of women who had inadequate care to adequate care)	Black—Birth weight in grams	124	169
		White—Birth weight in grams	83	319
		Hispanic—Birth weight in grams	138	311

Frank et al. (1992)	Percentage initiate care in first trimester	White—Percentage low birth weight births	–0.02	–0.007
			—†	(2.01)
		Black—Percentage low birth weight births	0.0009	–0.180
			—†	(2.00)
Corman, Joyce, and Grossman (1987)	3-year average of percentage beginning care in first trimester	White—3-year average neonatal mortality	–0.045	–0.076
			(5.40)	(5.14)
		Black—3-year average neonatal mortality	–0.030	–0.117
			(1.69)	(2.81)
Grossman and Joyce (1990)	Months delay (control for selection into live birth group)	White—Birth weight in grams	–4.384	–23.145
			(1.20)	(1.35)
		Black—Birth weight in grams	–12.380	–37.428
			(3.54)	(1.97)

*Results presented in grams; *t* scores in parentheses.
†Not available in published report.

that it is possible that women with similar levels of fetal health endowment cluster together geographically. This could be related to clustering by culture or ethnicity, social class, health consciousness, or other factors that are consistently related to birth outcomes.

Frank et al. used a fixed-effects model to analyze data from the same counties over time, looking at five 2-year periods rather than 10 single years. The fixed-effects model controls for the fact that the data set consists of repeated observations of the same counties over time. This method is analogous to a regression with an indicator for each county; thus, any effect of being in a county that is constant over time will be controlled. If a county has favorable birth outcomes over time because of a clustering of women with fetuses with excellent health endowments, this effect will appear in the county indicator and not affect the estimated effect of prenatal care on birth weight outcome. Separate regressions were run for Black and White birth outcomes for women 20-34 years of age. The dependent variable was the race-specific prevalence of low birth weight by county (i.e., the percentage of infants weighing less than 2,500 grams at birth). The independent variables in the regression included county-level measures of income, abortion rates, the percentage of births that were first births, the percentage of women initiating prenatal care in the first trimester, and a state-level measure of smoking. The authors referred to their models as "quasi-structural" birth weight production functions since income was included in the model as a control for the ability to purchase certain unmeasurable inputs. As discussed earlier, income typically has been treated as a structure variable that influences factors in the process of birth weight production but does not have a direct effect on birth weight.

The results indicated that prenatal care initiation in the first trimester led to a reduction in the rate of low birth weight for both Black and White women, although the estimates of the effects were considerably lower than those observed in cross-sectional studies using individual-level data (Table 2). The coefficients for prenatal care suggested that first-trimester utilization had a larger benefit for Black women than for White women. However, differences in the timing of prenatal care initiation explained only a small portion of the racial gap in the incidence of low birth weight. The model was re-estimated without controlling for the fact that the same counties are observed repeatedly; this provides potentially biased estimates that can be compared with the fixed-effect results to suggest the type of bias in the system. In the model without fixed effects, the impact of prenatal care fell in predominantly Black counties and increased in predominantly White counties. The comparison of the two sets of results implied the presence of adverse selection into prenatal

care among Black women and favorable selection for White women. Frank et al. (1992) concluded that increasing the proportion of women with early initiation of care would make a small contribution toward reducing the rate of low birth weight and reducing racial differences in birth outcomes.

In a 1994 article, Joyce attempted to estimate the impact of prenatal care on the entire population of Black, White, and Hispanic women 20 years of age and older having a live birth in New York City during 1984 ($N = 79{,}915$). The primary data are from New York City birth certificates, with a variety of other data used to augment the vital records, including 1980 census data aggregated to the health area level. The dependent variable was birth weight (in grams). The prenatal care equation included measures of the availability of medical care and reproductive health services, and local poverty rates. Prenatal care was measured using the modified Kessner Index, which categorized the care received as inadequate, intermediate, or adequate. The variables in the birth weight production function included private versus general service delivery, maternal age and age-squared, maternal education, parity, smoking and drug use, infant sex, plurality, Hispanic ethnicity, and whether or not the mother was foreign born. Separate regressions were run by race/ethnicity.

Joyce found that the OLS results regarding the effects of prenatal care on birth weight were underestimated at least 80% for White and Hispanic births and to a lesser degree for Black births (Table 2). The findings of this study, like those described above, point to the existence of adverse selection. Joyce also found that for the entire population under study, the gains from moving from inadequate to intermediate care were larger than the gains from moving from intermediate to adequate care. There are a number of potential explanations for this. First, there may simply be less of a benefit from additional prenatal care as more care is obtained. Second, without controlling for selection, the effects of obtaining more care are attenuated. Since the adequate group contains both women who have the correct number of visits for the length of gestation and women who have a large number of visits due to complications, the ability to control for selection into this group may be weaker than the ability to control for selection into the intermediate group.

Joyce considered this study "exploratory," and suggested that better specified models with more detailed data on maternal behaviors and prenatal care utilization are necessary to discover the "true" impact of prenatal care on birth weight. Joyce also suggested that a more specific set of health information might eliminate the need to include poverty as a proxy for unobservable influences on birth weight, especially among Black women. The effects of poverty are unclear. Joyce, however, also warned that "population heterogeneity insures that even if such unobserved factors as the health endowment

are randomly distributed among the population, as long as these elements are known to the individual, but not to the researcher, then the potential for selectivity bias will remain" (1994, p. 787).

B. SELECTIVITY AND OTHER OUTCOMES

There are a few published studies that incorporated selectivity in the use of prenatal care into models of birth outcomes other than birth weight. Corman, Joyce, and Grossman (1987) used county-level data for 1976-1978 to investigate the effect of prenatal care on neonatal mortality. In this case, health endowment was viewed as playing a role in decisions regarding prenatal care and in the probability of a neonatal death.

The model in this article used the 3-year average, race-specific neonatal mortality rate as the dependent variable, and 3-year average, race specific percentages of low birth weight rate as an explanatory variable. The low birth weight rate acted as a proxy for endowed survival probability. The data included counties with at least 50,000 persons in 1970 for White regressions and at least 5,000 Blacks in 1970 for Black regressions. The authors applied a two-stage least squares procedure for estimation. The two-stage results with prenatal care affecting both birth weight and neonatal mortality were significantly larger than the OLS effects of prenatal care on neonatal mortality, with larger differences for Black cases than for White cases (Table 2). Thus these authors provide additional evidence of adverse selection into prenatal care, with a particularly important effect for Black women.

We found one study on selectivity in prenatal care that considered a population outside of the United States. Panis and Lillard (1994) analyzed data from the 1988 Malaysia Family Life Survey, which provided cross-sectional and retrospective data at the household level. The primary equations Panis and Lillard estimated were hazard functions for fetal and postneonatal survival. The medical care utilization variables of interest included prenatal care and site of delivery (home versus medical institution). The only measure of prenatal care available was a dichotomous indicator of whether any prenatal care was obtained versus none. With two endogenous variables and two hazard functions, the system was estimated simultaneously. This also allowed the authors to control for selective fetal survival.

Prenatal care was found to significantly decrease the risk of fetal death even without controlling for adverse self-selection into the group of women who received prenatal care. As expected, however, the estimated effect was larger when controlling for self-selection. Prenatal care did not show a similar effect on postnatal survival, but institutional delivery did. Again, the effect was shown to be stronger when controlling for self-selection into the group who

had institutional deliveries. The applicability of some of these findings to the health care systems of the United States and other western industrialized countries is limited. Nonetheless, the results of Panis and Lillard suggest that medical care has a role to play in increasing infant health and survival in Malaysia.

Grossman and Joyce (1990) extended the discussion of selection by estimating a model in which a pregnant woman's decision to give birth rather than to abort was addressed. In this study, the authors used three equations: one to estimate the probability that the fetus is not aborted, a second to estimate the delay in seeking prenatal care, and a third to estimate birth weight. The data were from 1984 New York City vital records, supplemented with data from the 1980 census to provide information on poverty and health care provider availability by health area within New York City. Of the 105,000 live births and 90,000 induced abortions in 1984, the authors selected a random sample of 11,591 pregnancies for White, non-Hispanic women aged 20 or older, and 11,016 pregnancies for Black non-Hispanic women aged 20 or older.

Using a system of simultaneous equations, Grossman and Joyce demonstrated how the variance of unobservable factors such as the price of contraception, the price of abortion, and the health endowment each affect the correlation between the errors. The authors' results provided empirical evidence of selection in the use of induced abortion among Black women but not among Whites. These results imply that unobservable characteristics of Black women that were related to a decision to give birth were correlated with unobservables that had a positive effect on prenatal care utilization and on birth weight. Grossman and Joyce also found that women who had induced abortion had lower prenatal care on average; this had the effect of increasing the average use of prenatal care among Black women in New York City relative to what would be expected if those who had induced abortions had given birth instead.

Grossman and Joyce's comparison between the OLS and two-stage least squares results indicated that there may be adverse selection driving the demand for prenatal care (Table 2). When selection processes are taken into account, a 3-month delay in prenatal care was found to reduce birth weight by 69 grams (2.4 ounces) for White mothers and 112 grams (3.9 ounces) for Black mothers. The magnitude of the effect of prenatal care was less in these results than that observed in Rosenzweig and Schultz's research. Further, after controlling for the selection process of not having an abortion, there is little evidence of any selection effect in obtaining prenatal care. Thus the findings in previous research come under question when the decision to give birth is considered.

DISCUSSION AND FUTURE RESEARCH AGENDA

This article offers a conceptualization of the issue of selectivity in the use of prenatal care and a review of the published empirical studies that have characterized prenatal care selection processes and resulting biases in estimates of the association between prenatal care and birth outcomes. Taken together, the results of these studies suggest that selectivity in the demand for prenatal care does exist and that analyses that do not take selection processes into account will produce biased estimates of the effects of prenatal care. The majority of studies to date have concluded that the predominant selection process is one of adverse selection. This implies that analyses that fail to control for selectivity will *underestimate* the effect of prenatal care.

As outlined in Table 2, the degree of underestimation found varied by study. In most analyses, however, correcting for selectivity in prenatal care utilization did not lead to the conclusion that prenatal care utilization is a primary predictor of birth weight or neonatal mortality. Although late initiation of care or no prenatal care at all was statistically related to a poor birth outcome, prenatal care utilization does not appear to be a major determinant. The study results also suggest that, even after correcting for selection bias, expanding the early initiation of prenatal care would have a limited impact on birth weight in the general population and would make only a minor contribution in reducing racial differences in the low birth weight rate.

A clear strength of the literature reviewed here is the attention given to selection processes. By analytically separating the demand for prenatal care (a function of structure) from the birth weight production process, these studies have shed much additional light on the relationship between prenatal care utilization and birth outcomes. In addition, the studies reviewed have strengthened our understanding of other variables that both directly and indirectly influence birth outcomes.

There are, however, some limitations in the studies reviewed in this article. First, the instrumental variables econometric technique, which is intended to provide an unbiased estimate of the effects of prenatal care, can lead to problems of inconsistency and finite sample bias (Bound, Jaeger, and Baker 1995). Second, limitations in the study samples must be recognized. Of the eight studies reviewed here, the samples for three of them were restricted to New York City. Two of the four studies that involved a national sample of U.S. births used aggregate data from the county level rather than the individual level. In addition, most of the studies restricted their samples to women between the ages of 21 and 35, and none of the studies included women under the age of 18. While the reasoning behind the exclusions was sound, the results of these studies cannot be generalized beyond the scope of their study sam-

ples. Thus, at this time, we have a paucity of information in regard to several important policy issues, including the potential for prenatal care to improve birth outcomes for adolescents, older women, and nonurban minorities.

Third, the economic studies reviewed here were also limited by some of the same methodological and measurement issues that historically have complicated research on prenatal care and birth outcomes (Lantz and Partin 1995). One of these limitations is that the important concept of prenatal care was operationalized by considering only its use, and in most studies utilization was measured with the simple construct of "delay" (the month in which care was initiated). Other dimensions of prenatal care, including the content, quality, continuity, or comprehensiveness, were not considered. As such, these studies do not offer any insight into the mechanisms by which the adequate (i.e., early and/or frequent) use of prenatal care use has a positive impact on birth outcomes.

Fourth, the majority of the studies were based on birth certificate data. While we are fortunate to have a strong vital registration system in the United States, birth certificate data are limited in terms of the sociodemographic, economic, and medical care variables that are collected. As a result, analysts are severely limited in what can be used as instruments in two-stage analyses and in what can be considered in terms of structure and process variables. In addition, misclassification in the use of prenatal care could also be adding noise to models and leading to attenuation of estimates of the effect of prenatal care on birth weight. In a study using the three different data sources in the 1980 National Natality Survey, Lantz and Penrod (1995) provided evidence that measurement error in the use of prenatal care leads to underestimation of its impact on birth weight. These results suggest that part of what researchers have interpreted as selection bias may in fact be attenuation bias due to measurement error.

A fifth limitation of the studies reviewed here is a narrow conceptualization of selectivity in the use of prenatal care. Selection processes other than adverse selection were barely discussed, including what we define as "confidence selection," which would also lead to an underestimation of the relationship between prenatal and birth outcome. The result of a downward bias in the effect of prenatal care was uniformly interpreted as stemming from the unobserved process by which maternal knowledge of fetal health endowment led to adverse selection into prenatal care. Actually, however, we really do not know the cause of this bias; we only know that those selection processes that lead to downward bias predominate. This could be the result of a process by which some women with particularly poor fetal health endowments get earlier and/or more care compared to everyone else; some women with particular confidence about the health of their fetuses get later and/or less

care compared to everyone else, or a general trend that leads women with better fetal endowments to obtain later and/or less prenatal care.

Distinguishing between different types of selection is important because the policy implications of each type are unique. Knowing the degree to which each type exists and any patterns in the types of women affected will help to target policies and programs. For example, the biasing effects of favorable selection suggest that the potential for prenatal care to have an impact on birth outcomes is being overestimated and that a public health policy focus on the early initiation of care will meet with limited success. Conversely, if adverse selection is leading to underestimates of the effect of prenatal care on birth weight, then policy analysts need to consider the degree of bias and whether corrected estimates suggest that improvements in a population's overall use of prenatal care will actually have an impact on population birth outcomes. Estrangement selection suggests that it is women's socioeconomic characteristics and maternal behaviors that are leading to poor birth outcomes rather than the lack of prenatal care. While prenatal care may indeed help these women in myriad ways that are not related to birth weight, policy makers need to understand that if this type of selection process is in operation, simply increasing exposure to prenatal care may not result in improved birth weight results for this subpopulation of high-risk women. Finally, confidence selection suggests that for some types of women, the underuse of prenatal care does not have a negative impact on birth outcomes. Yet analysts need to recognize that the inability to separate these low-risk women from other women could lead to an underestimation of the true benefits of increased prenatal care use in the overall population.

We believe that an improved understanding of the role of prenatal care in producing positive birth outcomes is critical for the advancement of public health policy in this area and that additional research that addresses issues of selectivity is greatly needed. Based on the strengths and limitations of existing knowledge, we propose the following research agenda. First, additional research is needed to further conceptualize selection processes in the use of prenatal care and to empirically document the extent to which each of these processes exist. The economic research to date suggests that adverse selection in prenatal care initiation dominates any favorable selection that may be occurring. Our conceptualization of selection processes, however, also includes what we label as confidence selection and estrangement selection. At this time, there is scant information regarding the degree to which these types of selection processes are in operation and if they are associated with other maternal characteristics. We need to work to make these and other "unobservables" more observable. Richer descriptive information on the determinants of prenatal care utilization, including psychosocial factors related to

women's decisions regarding the initiation and overall use of care, is greatly needed.

Second, research is needed to improve the conceptualization of prenatal care, including our ability to identify multiple dimensions of care (such as utilization, content, quality, and continuity) and to measure the relative importance of these separate dimensions for specific birth outcomes. Well-designed research on the potential of "coordinated care" (or the packaging of prenatal care with social, economic, educational, and nutritional services) would make an important policy contribution. Third, there is a strong need for richer data for studying the determinants of birth weight and other outcomes. While the use of vital registration data offers a population-based sample, the available data elements are insufficient for a thorough and detailed analysis of selection processes and birth outcome determinants. Fourth, systematic consideration of birth outcomes in addition to birth weight is also needed. Different birth outcomes likely have different determinants, and we need to become more sophisticated in the ways in which these outcomes are conceptualized and measured in health services research. For example, the two major causes of low birth weight—prematurity and fetal growth retardation—should be analyzed separately (Kallan 1993). Fifth, research in which the effects of prenatal care selection bias and measurement error are controlled simultaneously needs to be conducted.

CONCLUSIONS

Our motivation in undertaking this review is a keen interest in the role of prenatal care in public health policies aimed at reducing poor birth outcomes in the United States. While many policies and programs have focused on providing early and continuous prenatal care—especially in populations considered to be at high risk—the empirical basis for this strong policy focus is unclear. The research results in this literature review suggest that selection processes in the use of prenatal care do have the potential to bias downward estimates of its impact on birth outcomes. On the other hand, however, the research results to date do not answer a number of questions about the appropriate role of prenatal care or other potential interventions in public health policy.

We believe that an improved understanding of selection processes in the use of prenatal care and other factors related to birth outcomes is essential to the further development of policies aimed at improving infant health and reducing racial disparities in reproductive outcomes. In this article, we have attempted to lay a foundation from which future empirical studies of the determinants of birth outcomes—including prenatal care—can emerge. The

research that is needed is quite challenging because of complexities in the types of data and the analytical tools that are required to assess the impact of both structure and process variables on birth outcomes. Nonetheless, without a clearer understanding of the factors that are related to both women's use of prenatal care and their birth outcomes, the role of prenatal care in policy responses to the serious infant health problems in the United States will remain a question mark.

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