Medicaid Costs and Birth Outcomes: The Effects of Prenatal WIC Participation and the Use of Prenatal Care

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Abstract

This study examines the effects of prenatal WIC participation and the use of prenatal care on Medicaid costs and birth outcomes in five states—Florida, Minnesota, North Carolina, South Carolina, and Texas. The study period is 1987 for Florida, Minnesota, North Carolina, and South Carolina and January–June 1988 for Texas. Prenatal WIC participation was associated with substantial savings in Medicaid costs during the first 60 days after birth, with estimates ranging from $277 in Minnesota to $598 in North Carolina. For every dollar spent on the prenatal WIC program, the associated savings in Medicaid costs during the first 60 days ranged from $1.77 to $3.13 across the five states. Receiving inadequate levels of prenatal care was associated with increases in Medicaid costs ranging from $210 in Florida to $1,184 in Minnesota. Prenatal WIC participation was associated with higher newborn birthweight, while receiving inadequate prenatal care was associated with lower birthweight.

Low birthweight and infant mortality are major public health concerns in the United States. The high social and economic costs associated with low birthweight are now widely recognized, and the high costs of caring for infants with low birthweight impose a large financial burden on the Medicaid program, the nation's primary program providing reimbursement for health care services to low-income women and their children. A large body of literature suggests that early and adequate prenatal care is effective in lowering the risk of adverse pregnancy outcomes. Recognizing this, Congress, during the 1980s, authorized a series of expansions of the Medicaid program specifically to improve access to health care for poor women and their children.

At the same time, evidence that good prenatal nutrition improves birth outcomes has prompted increased expenditures under the WIC program, which was authorized by Congress in 1972 to provide food supplements, nutritional risk assessments, nutrition education, and health and social service referrals to low-income pregnant and postpartum women, infants, and

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children up to age five. The program, which is federally funded and administered by state and local agencies, has become a major component of the maternal and child health services delivered at the state and local levels. In 1990, the WIC program served 4.5 million women and children at a cost of $2.1 billion.

Since both the WIC and Medicaid programs serve low-income pregnant women, an important issue is the extent to which prenatal participation in the WIC program and the use of prenatal care affect birth outcomes and the subsequent health-care costs of Medicaid-eligible women and their newborns. This article presents the results of a study of the birth outcomes and Medicaid costs for Medicaid beneficiaries in five states: Florida, Minnesota, North Carolina, South Carolina, and Texas.[1] The analysis addressed the following questions:

- What are the savings in Medicaid costs for mothers and their newborns from birth to 60 days after birth resulting from mothers' participation in the WIC program during pregnancy?
- Are the savings in Medicaid costs associated with prenatal WIC participation greater or less than the costs incurred by the WIC program to provide its services?
- What are the savings in Medicaid costs for mothers and their newborns from birth to 60 days after birth resulting from adequate versus inadequate levels of prenatal care?
- What are the effects of prenatal WIC participation and the adequacy of prenatal care on newborn birthweight and gestational age?

The study period was 1987 for Florida, Minnesota, North Carolina, and South Carolina, and the first six months of 1988 for Texas.

The first section of this article briefly reviews some previous research on the WIC program's effectiveness. The second section describes the data used in the analysis; the third discusses the methodological approach of the study. The following sections present estimates of the effects of prenatal WIC participation and the adequacy of prenatal care on Medicaid costs and birth outcomes.

PREVIOUS RESEARCH ON THE EFFECTS OF PRENATAL WIC PARTICIPATION

The WIC program has grown from a $750 million program serving 2 million women and children in 1980 to a $2.1 billion program serving 4.5 million women and children in 1990. Since its inception in 1972, the program has prospered under four separate administrations, in part because, at least on an intuitive level, the provision of food supplements to low-income, at-risk pregnant women, infants, and children seems that it should improve preg-

[1] These five states were selected after an extensive feasibility study, during which several factors were considered. One of the most important factors was the ability of the state staff to provide complex Medicaid, WIC, and Vital Statistics data extracts in a timely fashion to use for the analysis. Other factors considered for the selection of states were variations in perinatal outcomes, minority representation, geographic distribution, and the need to have some states with large urban areas.

nancy and health outcomes. However, as noted by Kennedy et al. [1982], while the benefit of nutritional supplementation for poor pregnant women has been demonstrated in developing countries, its efficacy in industrialized countries—where poor pregnant women are relatively better off—continues to come under scrutiny. In addition, both the size and growth of the WIC program have prompted policy- and lawmakers, as well as the scientific community, to call for efforts to quantify its benefits.

Thus, as the WIC program has grown in the 1970s and 1980s, it has been subjected to numerous and varied evaluations. Many evaluations have been carried out at the state and local level, with only a few at the national level. The outcomes examined include birthweight, fetal and neonatal mortality, medical conditions, and nutritional status in the mother and infant, and, less frequently, Medicaid and indigent-care cost savings at and around birth for prenatal WIC participants and their newborns. Important findings from the key evaluations are the following:

- The earliest evaluation, Edozien et al. [1979], was a national effort that involved over 50,000 women, infants, and children at 19 WIC projects in 14 states. Outcomes from clinical examinations and laboratory samples collected between 1973 (just a year after the inception of WIC) and 1976 for current WIC participants were compared with similar measures for new WIC enrollees collected at the time of their enrollment. The primary study finding was that WIC participation resulted in increased birthweight.
- Kennedy et al. [1982] compared medical and nutrition records collected between 1973 and 1978 for the births of 897 WIC participants with those of 410 pregnant women on WIC waiting lists or receiving health services at non-WIC facilities at nine sites in Massachusetts. WIC participants had higher average birthweights than nonparticipants (3,273 grams versus 3,136 grams).
- Kotelchuck et al. [1984] examined 4,126 matched pairs of births for WIC participants and nonparticipants. Data for the sample were obtained from 1978 birth and death certificates and WIC program records in Massachusetts. A small, nonsignificant increase in birthweight (from 3,260 to 3,281 grams) was estimated, as was a statistically significant decrease in the percent of low birthweight babies (from 8.7 to 6.9 percent), a decrease in infant mortality, and an improvement in the use of prenatal care. The estimated WIC impacts increased with the length of WIC participation.
- Schramm [1985, 1986, 1989] examined the effect of WIC participation on Medicaid costs after birth in Missouri at three points in time—1980, 1982, and 1985–86. For 1980 Medicaid births, Schramm estimated a savings of $.83 in newborn Medicaid reimbursements within 30 days after birth for each dollar spent on the prenatal component of the WIC program; in 1982 and 1985–86, the estimated Medicaid savings for services received within 45 days after birth were $.49 and $.79, respectively. Mean birthweight was 6 grams greater for WIC participants than for nonparticipants in 1980, compared with differences of 31 grams and 25 grams in 1982 and 1985–86, respectively.
- Rush [1987] compared longitudinal data on 5,205 prenatal WIC participants and 1,358 non-WIC registrants at prenatal clinics selected from

> 174 WIC sites and 55 clinics across the country. The primary findings concerning the effects of prenatal WIC participation were as follows: no statistically significant effect on newborn birthweight; increased infant head circumference; increased birthweight and head circumference with better WIC program quality; lower incidences of fetal death and low birthweight of appreciable but not significant magnitude; and increased intake of protein, iron, calcium, and vitamin C (4 of the 5 targeted WIC nutrients).

These evaluations shared a number of features. Each examined the ability of WIC participation to increase birthweight. Birthweight is known to predict subsequent short- and long-term health problems in newborns, such as respiratory difficulties and developmental disabilities [Institute of Medicine, 1985]. In addition, newborn birthweight is a relatively reliable quantitative measure that is routinely available on birth certificates, a major data source for these studies.

A second feature of these evaluation studies is that each identified a comparison group against which to compare outcomes, such as birthweight, for WIC prenatal participants. Ideally, the goal in selecting a comparison group is to identify a sample of women who are identical to WIC prenatal participants *except* for their participation, in order to see what would have happened to the WIC participants in the absence of the WIC program. However, as discussed in more detail in the next section, identifying such a group is difficult. As a result, researchers are confronted with the problem of interpreting differences in outcomes between WIC participants and comparisons in light of the measured and unmeasured differences that may have existed between the two groups.

DESCRIPTION OF DATABASE

One of the key analytic challenges to assessing the effects of the adequacy of prenatal care and prenatal WIC participation on Medicaid costs and birth outcomes was to construct an analysis database that contained information on Medicaid costs after birth, birth outcomes, prenatal care, and WIC participation. The database constructed for this study served four major purposes: (1) to identify Medicaid mothers and newborns; (2) to provide information on Medicaid costs from birth to 60 days after birth; (3) to determine whether the mother participated in the WIC program while pregnant; and (4) to provide information on birth outcomes and on the use of prenatal care. In each state, the analysis database was constructed from the linkage of three main state data files: the Medicaid paid claims and eligibility files, the WIC program files, and the Vital Records files. The following discussion is a brief summary of these state data files and the file linkage process used to construct the analysis database.

Medicaid, WIC, and Vital Records Data

Medicaid eligibility and paid claims files served two purposes: (1) to identify Medicaid-covered births; and (2) to provide data on Medicaid costs for the analysis. The analysis sample includes *all* Medicaid-covered births that occurred in 1987 in Florida, Minnesota, North Carolina, and South Carolina, and those in the first six months of 1988 in Texas. In Texas, the study is based on all Medicaid births that occurred during the period from January 1988 through June 1988, since the data necessary to identify WIC prenatal participants were not available for births in an earlier period.

Data from the states' WIC data systems were used to determine whether a Medicaid-covered mother was receiving WIC benefits while she was pregnant and, if so, the costs of providing the WIC food packages. For this study, prenatal WIC participation was defined as the following: for Florida, Minnesota, and North Carolina, if the women redeemed at least one food instrument during the nine months prior to birth; for South Carolina, if she was issued a food instrument during the nine months prior to birth; and, in Texas, if she had a WIC certification date sometime during the nine months prior to birth. WIC program costs are equal to the cost of the food packages provided to each participant plus administrative and nutrition education expenses per participant. State-level data on total WIC food costs and total administrative and nutrition education costs were used to calculate the ratio of administrative and nutrition education expenses to total WIC food costs.[2] This ratio was multiplied by the average food supplement cost per prenatal participant to calculate estimated administrative and nutrition education expenses per participant.

Data from the Vital Records birth certificate files retained for the study included sex, number, duration of gestation, and birthweight of newborns; age, race, ethnicity, education, and marital status of mothers; indicators of prenatal care; and number of previous live births and previous pregnancy terminations.

File Linkage and Descriptive Statistics

To conduct the analysis of the Medicaid cost savings due to WIC participation and the use of prenatal care, the data on Medicaid costs, WIC participation and costs, the use of prenatal care, and birth outcomes were combined for each Medicaid-covered birth. Overall, the WIC/Medicaid analysis database includes nearly 105,000 Medicaid births, as shown in Table 1. The proportion of these births occuring to WIC participants varied across the study states, ranging from nearly one-half of the Medicaid births in Texas to almost three-quaraters of the Medicaid births in South Carolina. Average Medicaid costs for mothers and newborns from birth to 60 days after birth varied across the states, ranging from $2,433 in South Carolina (hospital costs only) to $3,822 in Minnesota. Birth outcome data indicate that the average birthweight of Medicaid newborns in the study states was around seven pounds (3,180 grams), and approximately 11.5 percent of the Medicaid newborns were low birthweight (less than 2,500 grams, or 5.5 pounds). The average birthweight of Medicaid newborns ranged from 3,103 grams (6.83 pounds) in South Carolina to 3,295 grams (7.25 pounds) in Minnesota. The percentage of low-

[2] Unfortunately, no individual-level data were available from the WIC program records on the amount of nutrition education received or no social service referrals by the WIC program. As a result, it is not possible with the database used in this study to allocate any estimated WIC impacts to the various WIC components—food supplementation, nutrition education, and social service referrals.

Table 1. Descriptive data on Medicaid births: number of births, average Medicaid costs, birthweight, and prenatal care.

	Florida	Minnesota	North Carolina	South Carolina	Texas
Medicaid births	35,558	11,592	20,441	11,641	25,472
To WIC participants	20,476	7,997	14,039	8,543	12,180
To Nonparticipants	15,082	3,615	6,402	3,098	13,292
Percent WIC participants	57.6	68.8	68.7	73.4	47.8
Average Medicaid costs:					
Newborns and mothers[a]	$2,569	$3,822	$2,743	$2,433[b]	$3,248
Average birthweight (grams)	3,181	3,295	3,143	3,103	3,191
Percent low birthweight[c]	11.7	8.6	12.8	12.9	10.7
Prenatal care inadequate[d] (percent)	14.8	9.9	9.1	17.5	19.9
WIC participants	9.1	7.8	4.9	13.6	14.2
Nonparticipants	22.6	14.6	18.2	28.0	25.0
No prenatal care visits (percent)	5.7	2.0	3.0	3.7	6.4
WIC participants	1.7	0.9	0.5	1.3	3.2
Nonparticipants	11.1	4.3	8.4	10.2	9.3

Source: WIC/Medicaid database.
Note: Medicaid births include all Medicaid mothers and newborns that were matched with a Vital Records birth certificate.
[a] Includes Medicaid costs from birth to 60 days after birth. Births with costs ≤ $200 are excluded.
[b] Includes hospital costs only.
[c] Birthweight of less than 2,500 grams (5.5 pounds).
[d] Four or fewer prenatal care visits for a full-term pregnancy. Includes women with no prenatal care visits.

birthweight Medicaid newborns was highest in North Carolina and South Carolina (12.8 and 12.9 percent, respectively) and lowest in Minnesota (8.6 percent).

Differences in the adequacy of prenatal care for WIC participants and nonparticipants are striking. In all five states, Medicaid mothers who did not participate in the WIC program were approximately two to three times as likely to have received inadequate prenatal care as WIC participants, where inadequate prenatal care is defined as four or fewer visits for a full-term pregnancy and includes women with no prenatal care.[3] Overall, 9.6 percent of the WIC participants in the five study states received inadequate levels of prenatal care, in contrast to 22.4 percent of nonparticipants. Nonparticipants were also more likely to have no prenatal care visits than WIC participants. These findings are not surprising, since access to prenatal care for low-income women and WIC participation are linked in many states. However, these findings have important implications for the analysis of Medicaid costs and birth outcomes, since it is important to distinguish between the effects of WIC participation and the effects of the adequacy of prenatal care.

[3] The number of prenatal care visits used to categorize inadequate care for births less than 34 weeks gestation declines as the length of gestation decreases.

METHODOLOGY

The basic analytic approach used for measuring the savings in Medicaid costs and differences in birth outcomes attributable to the WIC program was to compare the Medicaid costs and birth outcomes of WIC participants with the Medicaid costs and birth outcomes of a comparison group. The comparison group used in this study consists of a group of Medicaid mothers, and their newborns, who did not participate in the WIC program during their pregnancy (nonparticipants). Such a comparison group is critical for providing information on what the Medicaid costs and birth outcomes for WIC participants would have been had the WIC program not existed.

One potential problem with this comparison-group approach is that both the measured and the unmeasured characteristics of WIC participants may differ from those of comparison women who do not participate in the WIC program. Multiple regression analysis is used to control for the measured differences between WIC participants and nonparticipants that may also influence Medicaid costs and birth outcomes. For example, the following regression equation depicts the model of Medicaid costs:

$$Y_i = X_i\beta + \delta_1 P_i + \delta_2 K_i + \varepsilon_i \qquad (1)$$

where the subscript i denotes a Medicaid-covered birth, Y represents Medicaid costs from birth to 60 days after birth, X is a set of observed variables thought to affect Medicaid costs, P is an indicator variable denoting participation in the WIC program, K is a variable denoting the adequacy of prenatal care, and ε is an error term. The coefficients, δ_1 and δ_2, in this equation, represent the effects of prenatal WIC participation and the adequacy of prenatal care on Medicaid costs, after differences in the observed characteristics (the X values) of WIC participants and nonparticipants are controlled for. *A priori*, we would expect that the signs of δ_1 and δ_2 would be negative, indicating savings in Medicaid costs from prenatal WIC participation and prenatal care.

However, estimating the effects of the WIC program can be complicated considerably if unmeasured differences between WIC participants and nonparticipants also influence pregnancy outcomes and Medicaid costs. For example, relative to other eligible women who do not participate in the WIC program, WIC participants may have greater access to or knowledge of public health programs, which may independently affect pregnancy outcomes. Such differences might lead to favorable pregnancy outcomes, and thus to lower Medicaid costs, even in the absence of the WIC program. Because this type of difference is unmeasured, particularly with the type of data available for this study, it is very difficult to isolate the effects of WIC participation on Medicaid costs from the effects of unmeasured differences.

The Medicaid costs examined in this study consist of reimbursements from birth to 60 days after birth. For services that started within the 60-day period after birth but extended beyond the 60-day period, the Medicaid reimbursements were prorated according to the proportion of the service period that occurred within the 60-day postpartum period. Four specific birth outcomes are examined: newborn birthweight, gestational age, the incidence of low birthweight, and the incidence of preterm birth. Newborn birthweight is measured in grams, and low birthweight is defined as birthweight less than 2,500 grams. Gestational age is measured in weeks, and preterm birth is defined as gestational age less than 37 weeks.

The adequacy of prenatal care is measured with a modified Kessner Index [Kessner et al., 1973]. The Kessner Index is one of the most commonly used measures of prenatal care adequacy. The index combines information on the month prenatal care started, the number of prenatal care visits recorded, and pregnancy gestation to categorize the adequacy of prenatal care. For a full-term pregnancy, adequate prenatal care is defined as nine or more visits, with the first visit occurring during the first trimester of pregnancy; inadequate care is defined as four or fewer visits. Intermediate care for a full-term pregnancy encompasses all levels of prenatal care in between adequate and inadequate care. Adequate care for preterm births (births before 37 weeks gestation) requires a decreasing number of prenatal care visits as the length of gestation decreases.

In addition to prenatal WIC participation and the adequacy of prenatal care, the following characteristics were assumed to be important predictors of Medicaid costs and birth outcomes: the sex of the newborn, multiple birth, mother's age, mother's race/ethnicity, marital status, the number of previous live births, the number of previous pregnancy terminations, mother's education, and whether the county of residence is urban or rural. These independent variables included in the Medicaid cost and birthweight regression equations were derived from data from the Vital Records birth file. Although the Vital Records data are relatively more standardized across states than either the Medicaid or WIC data systems, not all variables were available for all five states in the study.

STUDY FINDINGS: MEDICAID COSTS AND BIRTH OUTCOMES

Medicaid Costs from Birth to 60 Days After Birth

The principal finding from the analyses of Medicaid costs is that prenatal WIC participation is associated with substantial savings in Medicaid costs during the first 60 days after birth, as shown in Table 2. The estimated coefficients of prenatal WIC participation are large and, with the exception of Minnesota, highly significant. The estimated reductions in Medicaid costs from birth to 60 days after birth for newborns and mothers range from $277 in Minnesota to $598 in North Carolina, with intermediate values of $347, $493, and $565 for Florida, Texas, and South Carolina (hospital costs only), respectively.

Table 3 presents evidence on the range in the estimated savings in Medicaid costs during the first 60 days after birth attributable to prenatal WIC participation and compares the estimated Medicaid cost savings with the costs of providing prenatal WIC benefits. With the exception of Minnesota, the 95 percent confidence intervals indicate positive Medicaid cost savings during the first 60 days after birth, with point estimates ranging from $347 in Florida to $598 in North Carolina and the confidence interval estimates ranging from $253 in Florida to $781 in South Carolina. The final columns in the table show the estimated savings in Medicaid costs per dollar of WIC program costs—the cost of the WIC food benefits plus an adjustment for administrative expenses and nutrition education. All the point estimates of the ratios of Medicaid cost savings to WIC costs exceed one, suggesting that the savings in Medicaid costs from birth to 60 days after birth resulting from prenatal WIC participation

Table 2. Estimated regression coefficients for a model of the effect of prenatal WIC participation on Medicaid costs, birth to 60 days after birth: newborns and mothers (standard errors in parentheses).

	Coefficients ($)				
Explanatory variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	2,101**	2,710**	2,699**	2,828**	3,572**
	(134)	(383)	(176)	(277)	(151)
Prenatal WIC participation	−347**	−277	−598**	−565**	−493**
	(48)	(154)	(73)	(110)	(74)
Newborn characteristics					
Male[a]	113*	210	99	139	223**
	(46)	(138)	(64)	(94)	(72)
Multiple birth	7,626**	11,007**	8,001**	6,729**	9,428**
	(197)	(603)	(1,167)	(415)	(305)
Mother characteristics					
Age 18–19	123	−499	9	−296	−238
	(89)	(315)	(120)	(179)	(135)
Age 20–34	146	−249	112	−279	0
	(84)	(301)	(117)	(162)	(123)
Age 35 and over	797**	−155	699**	530	844**
	(162)	(490)	(251)	(344)	(238)
Black[b]	399**	1,090**	378**	−53	−176
	(54)	(250)	(77)	(120)	(100)
Hispanic[b]	226**	—	—	—	−319**
	(86)				(91)
Native American	—	−18	—	—	—
		(274)			
Asian	—	−787**	—	—	—
		(334)			
Other race/ethnicity[b]	−351	—	—	—	−213
	(278)				(213)
Not married	20	80	−148	−86	−100
	(53)	(156)	(81)	(114)	(78)
Kessner Index intermediate	−105*	390*	289**	0	−123
	(51)	(161)	(69)	(108)	(85)
Kessner Index inadequate	210**	1,184**	542**	623**	292**
	(73)	(254)	(128)	(144)	(106)
Kessner Index unknown	511**	1,663**	1,252**	685	654**
	(134)	(225)	(184)	(362)	(144)
Previous live births (number)	−41	−155*	−162**	–	−128**
	(20)	(60)	(33)		(29)
Pregnancy terminations ≤ 20 weeks	—	316**	—	—	—
		(95)			
Pregnancy terminations > 20 weeks	—	484	224**	—	678**
		(433)	(58)		(153)
Education < 9 Years	8	691	428*	229	—
	(113)	(425)	(169)	(242)	
Education 9–11 Years	50	496*	40	102	—
	(83)	(236)	(116)	(172)	
Education 12 Years	47	72	−12	−62	—
	(78)	(208)	(107)	(164)	
Education missing	—	376	−183	1,726**	—
		(312)	(846)	(654)	

Table 2. (*Continued*)

Explanatory variables	Coefficients ($)				
	Florida	Minnesota	North Carolina	South Carolina	Texas
Urban	117	952**	220**	81	—
	(69)	(154)	(65)	(96)	
R^2	.052	.049	.015	.031	.045
Sample size	30,968	10,441	17,135	10,879	23,787

Source: WIC/Medicaid database.
Note: The unit of observation is the birth event. Observations with Medicaid costs from birth to 60 days after birth ≤ $200 are excluded.
[a] For multiple births, the binary variable "Male" is coded 1 if at least one of the newborns was a male.
[b] Racial/ethnic groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, non-Spanish,"; "Hispanic" means "Mexican"; and "other race/ethnicity" means "other Hispanic." In Florida, "other race/ethnicity" means "Native American or Asian."
* (**): Significant at the 0.05 (0.01) level, two-tail test.
—: Not available.

are greater than the costs of providing the prenatal WIC benefits. These point estimates range from 1.77 for Florida to 3.13 for North Carolina, with values of 1.83 for Minnesota and 2.44 for both South Carolina and Texas. Thus, in the five states included in this study, every dollar spent on the prenatal WIC program is associated with reductions in Medicaid costs for newborns and mothers during the first 60 days after birth that range from $1.77 to $3.13. Moreover, with the exception of Minnesota, the 95 percent confidence intervals for the ratios of Medicaid cost savings to WIC costs indicate ratios exceeding one.

These estimated ratios of Medicaid cost savings to the costs of providing prenatal WIC benefits are larger than those reported in similar studies by Wayne Schramm for the state of Missouri [Schramm, 1985, 1986, 1989]. In addition to variations in the WIC and Medicaid programs across states, one important difference is the definition of Medicaid costs from birth to 60 days after birth. The definition in this study includes reimbursements for all Medicaid claims whose *start* date of service was at or before 60 days after birth, and claims that extend beyond the 60-day postpartum period are prorated according to the proportion of the claim period that falls within the 60-day postpartum period. The definition used in the Schramm studies includes reimbursements for all Medicaid claims whose *end* date of service was at or before the cutoff date (30 days in 1980; 45 days in 1982 and 1985–86). Thus, the definition of Medicaid costs in this study is more inclusive and includes more claims for higher-cost births, particularly those whose claims extended beyond the postpartum period. Yet a third definition of Medicaid costs from birth through 60 days, and one that is discussed in a larger report from this study [Devaney et al., 1991], includes all reimbursements (that is, with no prorations) for claims whose *start* date of service was within 60 days of birth. Thus, the definition used for the analytical results presented in Tables 2 and

Table 3. Comparison of savings in Medicaid costs with prenatal WIC program costs.

	Florida	Minnesota	North Carolina	South Carolina[b]	Texas
Estimated savings in Medicaid costs[a]					
Point estimate	$347	$277	$598	$265	$493
95% confidence interval					
Lower limit	$253	−$25	$454	$349	$348
Upper limit	$441	$579	$741	$781	$638
Prenatal WIC program costs, per participant	$196	$151	$191	$232	$202
Savings in Medicaid costs/prenatal WIC costs					
Point estimate	1.77	1.83	3.13	2.44	2.44
95% confidence interval					
Lower limit	1.29	−.17	2.38	1.50	1.72
Upper limit	2.25	3.83	3.88	3.37	3.16

Source: WIC/Medicaid database.
[a] Medicaid costs are from birth to 60 days after birth.
[b] Medicaid costs refer to hospital costs only.

3 falls in the middle between the more inclusive and less inclusive of the possible definitions of Medicaid costs from birth through 60 days.

An important caveat to these findings is that the estimated savings in Medicaid costs associated with prenatal WIC participation are not independent of any unmeasured differences between WIC participants and nonparticipants that may also influence birth outcomes and Medicaid costs. WIC participants are a self-selected group of women who may choose to participate in the WIC program for underlying reasons that may independently lead to lower Medicaid costs. For example, some pregnant women may not participate in the WIC program because they lack access to or knowledge of publicly funded programs that provide health-care or other services, which may independently affect pregnancy outcomes. Thus, the estimated savings in Medicaid costs related to prenatal WIC participation may overstate the true savings since, relative to nonparticipants, WIC participants would have lower Medicaid costs even in the absence of the WIC program. Conversely, if the WIC program is successful at reaching high-risk, low-income pregnant women, WIC participants may be more likely to have higher-cost pregnancy outcomes than nonparticipants, and the estimated savings in Medicaid costs would understate the true savings associated with prenatal WIC participation.

In the absence of a true experimental research design in which WIC-eligible pregnant women would be randomly assigned to treatment and control groups, it is extremely difficult to control for the effects of self-selection when estimating the effects of prenatal WIC participation on Medicaid costs and birth outcomes. However, the problem introduced by self-selection may be offset to some extent by the facts that: (1) the adequacy of prenatal care is also likely to be related to any such underlying differences between WIC participants and nonparticipants, and (2) the analysis was able to adjust the estimated savings in Medicaid costs associated with prenatal WIC participation for the adequacy of prenatal care. Recall that WIC participants were much less likely than nonparticipants to have received inadequate levels of prenatal care (see Table 1); overall, 9.6 percent of WIC participants versus 22.4 percent of nonparticipants in the five study states had inadequate levels of prenatal care. By including variables for the adequacy of prenatal care in the Medicaid cost regressions, it is possible that the important differences between WIC participants and nonparticipants were effectively controlled for. However, the potential implications of the self-selection issue should be kept in mind when interpreting and generalizing the study findings.[4]

Table 2 also presents estimates of the effects of prenatal care on Medicaid costs. The coefficients of the Kessner Index variables indicate considerable Medicaid cost savings for newborns and mothers during the 60-day postpartum period associated with adequate or intermediate levels of prenatal care relative to inadequate levels of care. The estimated increases in Medicaid costs from birth through 60 days associated with inadequate versus adequate levels of prenatal care range from $210 in Florida, to $1,184 in Minnesota, with values of $292, $542, and $623 for Texas, North Carolina, and South Carolina, respectively. Interestingly, the estimated coefficients of the variable denoting intermediate levels of prenatal care vary in both sign and magnitude across the states, indicating no consistent effects of receiving intermediate versus adequate levels of prenatal care. In Minnesota and North Carolina, Medicaid costs from birth to 60 days after birth are higher for intermediate versus adequate levels of prenatal care, while in Florida and Texas the opposite is the case.[5]

The relationship between the adequacy of prenatal care and Medicaid costs is strongest in Minnesota. Relative to the estimated Medicaid costs for women who received adequate levels of prenatal care (the omitted category in the regression equation), the estimated Medicaid costs from birth to 60 days after birth for newborns and mothers are $390 greater for women who received intermediate levels of prenatal care, and $1,184 greater for women who received inadequate levels of prenatal care.

Finally, the estimated effects of race and ethnicity on Medicaid costs vary considerably across the study states. In Florida, Minnesota, and North Carolina, estimated Medicaid costs from birth to 60 days after birth for newborns and mothers are higher for black women than for white women (the omitted category). In Florida, being Hispanic is associated with increased Medicaid

[4] We estimated several selection bias models in which equations for Medicaid costs and prenatal WIC participation were jointly estimated. Unfortunately, because of the very limited set of independent variables from the birth files, the selection bias models estimated for this study yielded very unrealistic results that were extremely sensitive to both minor changes in model specification and the estimation procedure employed. Several different estimation procedures were used in an attempt to rely on fewer distributional assumptions concerning the error structure, and virtually every possible variable was used in the analysis in order to identify the determinants of prenatal WIC participation and Medicaid costs. The basic problem was that the predictive power of the WIC participation equation was poor, and both WIC participants and nonparticipants had roughly equal predicted probabilities of prenatal WIC participation. As a result, any correction for selection bias (either the two-stage Heckman correction or an instrumental variable for prenatal WIC participation) led to extreme multicollinearity, unrealistic model coefficients, and huge standard errors for all the model coefficients.

[5] One possible explanation for the estimated lower levels of Medicaid costs for intermediate versus adequate levels of prenatal care in Florida and Texas is that high-risk pregnancies might also be those with more intensive use of prenatal care.

costs from birth to 60 days after birth for mothers and newborns, while the opposite is true in Texas. Finally, estimated Medicaid costs during the first 60 days after birth for Asian women in Minnesota are significantly less than for any other racial and ethnic subgroup.

Birth Outcomes

An analysis of the effects of prenatal WIC participation on birth outcomes is important for understanding the possible sources of the Medicaid cost savings discussed above. This section presents results from an analysis of the effects of prenatal WIC participation and the adequacy of prenatal care on four measures of birth outcomes: birthweight, the probability of low birthweight, gestational age, and the probability of preterm birth.

Prenatal WIC participation by Medicaid beneficiaries is consistently associated with increased birthweight, as shown in Table 4. The average increase in birthweight ranged from 51 grams in Minnesota to 73 and 77 grams in Florida and Texas, to 113 and 117 grams in South Carolina and North Carolina, respectively. In general, the pattern of the estimated effects of prenatal WIC participation on birthweight is consistent with the explanation that low birthweight newborns tend to be higher-cost births. In particular, the smallest effects of prenatal WIC participation on birthweight and Medicaid costs were observed in Minnesota, while the largest effects for birthweight and costs were observed in North Carolina and South Carolina.

In all five states, receiving inadequate levels of prenatal care is associated with lower average birthweights of Medicaid newborns. The estimated coefficients of inadequate Kessner Index are all negative and highly significant and range from a reduction in average birthweight of 129 grams in Texas to 243 grams in North Carolina. Intermediate levels of prenatal care are also associated with lower average birthweight of Medicaid newborns, although the estimated coefficients are statistically significant only for Minnesota and North Carolina. Medicaid mothers with missing data on the Kessner Index have newborns with lower average birthweights than Medicaid mothers with adequate or intermediate levels of prenatal care.

The coefficients on the race/ethnicity variables in Table 4 show that newborns of black mothers receiving Medicaid have lower average birthweights than newborns of white mothers receiving Medicaid, after controlling for WIC participation, plurality, age, prenatal care adequacy, marital status, pregnancy history, and mother's education. In Minnesota, average birthweight is significantly lower for newborns of Asian mothers receiving Medicaid, and significantly higher for newborns of Native American mothers receiving Medicaid than for newborns of white Medicaid mothers.

Table 5 presents summary results of analyses of the incidence of low birthweight, gestational age, and the incidence of preterm birth. The low birthweight analysis uses a dichotomous dependent variable equal to one if newborn birthweight is less than 2,500 grams (5.5 pounds) and equal to zero otherwise. Gestational age is a continuous variable measured in weeks, and the incidence of preterm birth categorizes gestational age as a dichotomous variable equal to one if gestational age at delivery is less than 37 weeks and equal to zero otherwise. Due to the level of detail, only the estimated effects of prenatal WIC participation and the adequacy of prenatal care are presented, and complete sets of results are available from the authors.

Table 4. Estimated regression coefficients for a model of newborn birthweight (standard errors in parentheses).

	Coefficients (grams)				
Explanatory variables	Florida	Minnesota	North Carolina	South Carolina	Texas
Intercept	3,308**	3,370**	3,272**	3,215**	3,126**
	(19)	(30)	(24)	(32)	(16)
Prenatal WIC participation	73**	51**	117**	113**	77**
	(7)	(12)	(10)	(13)	(8)
Newborn characteristics	128**	122**	112**	101**	116**
Male	(7)	(11)	(9)	(11)	(8)
Multiple birth	−983**	−921**	−994**	−958**	−961**
	(23)	(34)	(27)	(36)	(24)
Mother characteristics					
Age 18–19	12	−1	9	28	52**
	(13)	(24)	(16)	(21)	(14)
Age 20–34	−12	−22	−12	45*	51**
	(12)	(23)	(16)	(19)	(13)
Age 35 and over	−73**	−42	−39	17	95**
	(24)	(38)	(34)	(40)	(25)
Black[a]	−189**	−218**	−174**	−162**	−127**
	(8)	(20)	(10)	(14)	(11)
Hispanic[a]	7	—	—	—	17
	(13)				(9)
Native American	—	129**	—	—	—
		(22)			
Asian	—	−146**	—	—	—
		(27)			
Other race/ethnicity[a]	−117**	—	—	—	23
	(40)				(22)
Not married	−57**	39**	−6	−67**	−34**
	(8)	(12)	(11)	(13)	(8)
Kessner Index, intermediate	−11	−55	−117**	−11	−8
	(7)	(13)	(9)	(13)	(9)
Kessner Index, inadequate	−195**	−238**	−243**	−144**	−129**
	(11)	(20)	(17)	(17)	(11)
Kessner Index, unknown	−129**	−146**	−218**	−201**	−94**
	(20)	(18)	(25)	(42)	(15)
Previous live births (number)	14**	40**	40**	—	23**
	(3)	(5)	(4)		(3)
Pregnancy terminations ≤ 20 weeks	—	−31**	—	—	—
		(8)			
Pregnancy terminations > 20 weeks	—	−88*	−50**	—	−76**
		(35)	(8)		(16)
Education < 9 years	−53**	−143**	−138**	−101**	—
	(17)	(34)	(23)	(28)	
Education 9–11 years	−64**	−155**	−94**	−84**	—
	(12)	(19)	(16)	(20)	
Education 12 years	−19	−84**	−39**	−31	—
	(11)	(16)	(15)	(19)	
Education missing	—	−129**	−41	−317**	—
		(24)	(116)	(77)	

Table 4. (*Continued*)

Explanatory variables	Coefficients (grams)				
	Florida	Minnesota	North Carolina	South Carolina	Texas
Urban	−14	−3	−20*	−3	—
	(10)	(12)	(9)	(11)	
Prenatal care from public health clinic	24*	—	—	—	—
	(10)				
R^2	.113	.118	.109	.105	.091
Sample size	31,732	11,547	20,688	11,733	25,710

Source: WIC/Medicaid data base.
Note: The unit of observation is the newborn.
* (**): Significant at the 0.05 (0.01) level, two-tailed test.
[a] Racial/ethnicity groups varied across states. In North Carolina and South Carolina, a small number of women classified neither as white nor black are included with black women. In Texas, "black" means "black, non-Spanish"; "Hispanic" means "Mexican"; and "Other race/ethnicity" means "other Hispanic." In Florida, "other race/ethnicity" means "Native American or Asian."

Prenatal WIC participation by Medicaid beneficiaries is associated with a lower incidence of low birthweight and preterm delivery and increased gestational age. The estimated reduction in the percentage of Medicaid mothers who had low birthweight newborns due to prenatal WIC participation ranged from 2.2 percentage points in Minnesota to 5.1 percentage points in North Carolina and South Carolina. Similarly the reduction in the percentage of women with preterm births ranged from 2.3 percentage points in Minnesota to 6.3 percentage points in South Carolina. Infants born to Medicaid-covered prenatal WIC participants also had longer gestations than nonparticipants, ranging from between .25 weeks and .75 weeks longer for Minnesota and North Carolina, respectively, with intermediate estimates of .39 weeks for Florida, .42 weeks for Texas, and .62 weeks for South Carolina. These estimated gestational age and preterm birth effects should be interpreted with some caution, however, given some technical issues discussed below with respect to the timing of enrollment in the WIC program.

As with the findings for Medicaid costs and newborn birthweight, inadequate prenatal care is associated with adverse pregnancy outcomes as compared with either intermediate or adequate levels of prenatal care. The incidence of low birthweight and the incidence of preterm birth are significantly higher for Medicaid mothers with inadequate levels of prenatal care than for mothers with either adequate or intermediate levels of prenatal care. Infants born to Medicaid mothers receiving inadequate levels of prenatal care also had significantly shorter gestations than Medicaid mothers with adequate or intermediate levels of care.

THE TIMING OF WIC ENROLLMENT

The WIC participation variable included in the main set of regression equations is a simple binary variable that equals one if the women participated

Table 5. Estimated effects of prenatal WIC participation and prenatal care adequacy on low birthweight, gestational age, and preterm birth.

	Incidence of low birthweight[a] (percent)	Gestational age[b] (weeks)	Incidence of preterm birth[a,c] (percent)
Florida			
Prenatal WIC participation	−3.3**	.39**	−3.5**
Prenatal care inadequate	7.2**	−.64**	6.4**
Prenatal care intermediate	0.1	.06	.1
Minnesota			
Prenatal WIC participation	−2.2**	.25**	−2.3**
Prenatal care inadequate	7.8**	−.87**	10.0**
Prenatal care intermediate	1.4**	−.14**	1.0
North Carolina			
Prenatal WIC participation	−5.1**	.75**	−5.4**
Prenatal care inadequate	9.4**	−1.15**	14.0**
Prenatal care intermediate	5.2**	−.77**	12.7**
South Carolina			
Prenatal WIC participation	−5.1**	.62**	−6.3**
Prenatal care inadequate	6.6**	−.23**	6.9**
Prenatal care intermediate	0.7	.16*	0.6
Texas			
Prenatal WIC participation	−3.4**	.42**	−4.2**
Prenatal care inadequate	4.5**	.42**	5.4**
Prenatal care intermediate	0.1	.10*	0.6

Source: WIC/Medicaid database.
Note: Complete sets of estimates are available from the authors.
* (**): Significant at the 0.05 (0.01) level.
[a] Estimated with probit.
[b] Estimated with OLS regression.
[c] Preterm births are those with a gestational age of less than 37 weeks.

in the WIC program during her pregnancy, and zero otherwise. Two closely related issues are associated with this definition of prenatal WIC participation: (1) This specification does not provide information on whether prenatal WIC participation has a dose-response effect; and (2) women who enroll in the WIC program at different points during pregnancy may have different risk factors for adverse pregnancy outcomes. This section presents additional analytic results from an investigation of these issues.

An analysis of a WIC dose-response effect is complicated by the fact that the duration of prenatal WIC participation is inevitably confounded with the effect of gestational age. Women whose durations of prenatal WIC participation are longer also have newborns with higher gestational-ages, which, on average, are lower-cost newborns with higher birthweights than low gestational-age newborns. Thus, the estimated coefficient of a variable for the duration of prenatal WIC participation in a regression equation for Medicaid costs is negative (i.e., positive savings) and highly significant, yet it is impossible to distinguish between the true effects of the duration of participation and the effects of increased gestational age. Put differently, women who have longer durations of prenatal WIC participation are likely to have lower Medicaid costs and newborns with higher birthweight simply because their pregnancies are longer, and it would be incorrect to attribute the effect of the duration of pregnancy on Medicaid costs and birth outcomes to the duration of WIC participation.[6]

One approach to estimating a dose-response effect is to examine the effect of early versus late enrollment in the WIC program. With this approach, the birth outcomes and Medicaid costs for women who enroll in the WIC program early during pregnancy (that is, during the first trimester of pregnancy) are compared with the birth outcomes and Medicaid costs for women who enroll later during pregnancy *and* with the Medicaid costs for nonparticipants. If WIC participation has a dose-response effect, the Medicaid costs during the first 60 days after birth would be lower and birthweight higher for early enrollees in the WIC program relative to later enrollees.

However, this approach to the dose-response issue has the same problem of confounding gestational age and late enrollment in the WIC program. That is, the group of WIC participants who enroll after the first trimester include some women who enroll late in their pregnancy. The pregnancy outcomes are likely to be more favorable and Medicaid costs less for this group of late enrollees relative to early enrollees in the WIC program for reasons that are related mostly to longer pregnancy durations rather than to WIC participation. In addition, for the very late enrollees (e.g., after 36 weeks gestation), there is the potential for an overstatement of the effects of prenatal WIC participation since Medicaid costs for these late WIC enrollees with longer gestational ages are compared with the Medicaid costs for nonparticipants, some of whom have high-cost, low-gestational age births and do not have the opportunity to enroll later as prenatal WIC participants.

To examine these issues, Table 6 presents selected results from two different specifications of the newborn and maternal Medicaid cost regression equation and the birthweight regression equation: (1) the basic model, as shown in Tables 2 and 4, and (2) a model with the same set of independent variables from the basic model *and* two additional independent variables—first trimester WIC enrollment and gestational age.

The first row in Table 6 shows the regression estimates discussed previously of the effects of prenatal WIC participation on newborn and maternal Medicaid costs. The second set of results presents estimated coefficients for prenatal WIC participation, first trimester WIC enrollment, and gestational age. These results should be considered illustrative, however, and interpreted with caution for two important reasons. First, gestational age is an outcome variable itself, and both gestational age and prenatal WIC participation are simultaneously related. The data for this study do not allow for the specification and estimation of a model of gestational age and prenatal WIC participation. Second, data on gestational age are of questionable quality and often are missing on birth certificates. Adding gestational age as an independent variable in the Medicaid cost and birthweight regression equations leads to the exclusion of cases with missing data on gestational age, and cases with miss-

[6] However, to the extent that prenatal WIC participation increases gestational age and reduces the incidence of premature deliveries, part of the effect of increased length of pregnancy should be attributed to prenatal WIC participation. As discussed below, it is indeed because gestational age and prenatal WIC participation are related that the relatively simple solution of including gestational age as an independent variable in the Medicaid cost regressions does not solve the problem.

Table 6. Estimated effects of prenatal WIC participation and WIC enrollment in the first trimester on Medicaid costs and birthweight (standard errors in parentheses).

	Florida	Minnesota	North Carolina	South Carolina	Texas
Dependent variable: Medicaid costs[a]					
Prenatal WIC participation	−347**	−277	−598**	−565**	−493**
	(48)	(154)	(73)	(110)	(74)
Prenatal WIC participation	−154**	122	−237**	−247*	−207**
	(47)	(156)	(71)	(117)	(73)
WIC enrollment in first trimester	−147	10	−104	−38	−255
	(81)	(151)	(87)	(107)	(135)
Gestational age	−402**	−1,340**	−445**	−447**	−537**
	(7)	(26)	(9)	(14)	(11)
Dependent variable: Birthweight					
Prenatal WIC participation	73**	51**	117**	113**	77**
	(7)	(12)	(10)	(13)	(8)
Prenatal WIC participation	25**	−5	32**	47	26**
	(6)	(11)	(9)	(13)	(7)
WIC enrollment in first trimester	73**	35**	63**	29*	71*
	(11)	(11)	(11)	(12)	(14)
Gestational age	87**	150**	87**	84**	88**
	(1)	(2)	(1)	(2)	(1)

Source: WIC/Medicaid database.
* (**) Significant at the 0.05 (0.01) level.
[a] Medicaid costs are for newborns and mothers from birth through 60 days after birth.

ing gestational age tend to be low-birthweight and high-cost births (see, e.g., the estimated coefficients on Kessner Index missing in Tables 2 and 4).

With these caveats in mind, it is interesting to assess (1) the estimated effects of prenatal WIC participation with and without gestational age as an independent variable, and (2) the estimated effects of first trimester WIC enrollment. Except for Minnesota, adding gestational age to the Medicaid cost regression equations reduces the estimated coefficients on prenatal WIC participation to roughly 40–45 percent of the original estimates (in absolute value). Except for Minnesota, these estimates are all statistically significant and suggest that Medicaid costs from birth to 60 days after birth are significantly lower for prenatal WIC participants *at each level of gestational age.* Thus, approximately 40–45 percent of the overall estimated effect of prenatal WIC participation on Medicaid costs is attributable to reduced gestational-age-specific Medicaid costs. These estimates do not imply that controlling for gestational age necessarily reduces the overall effect of prenatal WIC participation since, as noted above, prenatal WIC participation also influences gestational age, which in turn, affects Medicaid costs.

First trimester WIC enrollees generally have lower Medicaid costs during the first 60 days after birth than do later WIC enrollees (except for Minnesota). However, the estimated coefficients of first trimester WIC enrollment are not statistically significant at conventional two-tailed significance levels, although, for Florida and Texas, the estimated coefficients are of appreciable magnitude and are significant at conventional one-tailed significance levels.

Estimated coefficients for prenatal WIC participation, first trimester WIC enrollment, and gestational age in a model of newborn birthweight are presented in the bottom panel (second cell) of Table 6. The most striking finding is that average newborn birthweight is higher for first trimester WIC enrollees than for later enrollees. In all five states, the estimated coefficients of first trimester WIC enrollment are highly significant and of appreciable magnitude, ranging from 29 grams in South Carolina to 73 grams in Florida. The sum of the coefficients of prenatal WIC participation and first trimester WIC enrollment gives the *overall* estimated effect of prenatal WIC participation for first trimester WIC enrollees relative to nonparticipants, after controlling for gestational age. Thus, enrollment in the first trimester of pregnancy is associated with increases in newborn birthweight that ranged from 30 grams in Minnesota to 76 grams in South Carolina to 95 grams, 97 grams, and 98 grams in North Carolina, Texas, and Florida, respectively.

These findings are generally consistent with the findings from the analysis of Medicaid costs discussed above. That is, higher average newborn birthweight for first trimester WIC enrollees is generally reflected by lower levels of newborn and maternal Medicaid costs. However, the estimated coefficients of first trimester WIC enrollment in the Medicaid cost regression equations are not statistically significant at conventional two-tailed levels, in contrast to the highly significant coefficients in the birthweight regression equations. These findings suggest that prenatal WIC participation may have beneficial effects on birth outcomes that are not fully reflected by reductions in Medicaid costs.[7]

SUMMARY AND CONCLUSIONS

The results of this study indicate that prenatal participation in the WIC program improves birth outcomes and generates savings in Medicaid costs for mothers and newborns. In all five study states, the benefit–cost estimates are greater than 1 when the estimated savings in Medicaid costs are compared with the costs of providing prenatal WIC benefits. The study also suggests that receiving adequate versus inadequate levels of prenatal care has an independent beneficial effect on birth outcomes and Medicaid costs.

Since the analysis period of the WIC/Medicaid study (1987), major changes have occurred in the Medicaid and WIC programs and in the environments in which these programs operate. Thus, the long-term stability of the study results is an important issue. Higher Medicaid income-eligibility ceilings for pregnant women, in conjunction with increased coordination between the Medicaid and WIC programs, means that a higher-income group of women is likely to participate in the WIC programs. If prenatal WIC participation is more beneficial for lower-income women, then the benefits of prenatal WIC participation observed in 1987 may be greater than what would be observed under the current Medicaid income-eligibility standard for pregnant women

[7] For example, first trimester WIC enrollees may be heavier than average users of publicly funded health care, which translates into higher than expected use of health-care services after birth (e.g., postpartum checkups, infant checkups).

of 133 percent of the federal poverty level. On the other hand, aggressive outreach, streamlined eligibility procedures, and the growing problem of substance abuse may bring a higher-risk group of pregnant women into both the Medicaid and WIC programs. The net effect of these changes is uncertain.

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