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Does Greater Exposure to WIC Affect Maternal Behavior and Improve Infant Health? Evidence from the Pregnancy Nutrition Surveillance System

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Abstract

Recent analyses have reached differing conclusions on how effectively the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) improves infant health. We use 1996–2003 data from North Carolina's Pregnancy Nutrition Surveillance System to address limitations in previous work. With information on the mother's timing of WIC enrollment, we test whether greater exposure to WIC is associated with less smoking, greater weight gain, and better birth outcomes. Our results suggest that much of the often-reported association between WIC and lower rates of preterm birth is likely spurious, the result of gestational age bias. We find at best modest effects of WIC on fetal growth, but no association between WIC and smoking. A series of falsification tests provide additional evidence that the robust association between WIC and preterm birth from observational studies is likely specious.

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INTRODUCTION

The conclusion among policy analysts has been that "WIC works." The 1992 General Accounting Office report concluded that every $1.00 spent on WIC saves the government $3.50 in averted newborn costs (General Accounting Office, 1992). A more recent review of WIC's 31-year history reached similar conclusions.[1] The report cites new work by economists who found that participation in WIC was associated with a 29 percent reduction in low birth weight and more than a 50 percent reduction in very low birth weight (Bitler and Currie, 2005a).

However, Besharov and Germanis (2001) and more recently Joyce, Gibson, and Colman (2005) have challenged the prevailing wisdom. Besharov and Germanis (2001) reviewed the literature and concluded that evidence linking WIC to improved birth outcomes was dated and based on weak designs that were vulnerable to contamination by selection bias. Joyce, Gibson, and Colman (2005) analyzed over 800,000 births to women on Medicaid in New York City between 1988 and 2001. They found little association between WIC and fetal growth. They did find that WIC was strongly associated with preterm birth, but concluded that the association was likely spurious since effects were implausibly large, limited to U.S.-born blacks, and diminished over time.

Bitler and Currie (2005b) challenged such skepticism, arguing that WIC provides more than nutritional supplementation and that the bundle of services associated with WIC creates health-enhancing synergies:

> It is entirely possible that the main benefit of WIC is not the provision of food per se, but the fact that the "carrot" of food packages induces women to initiate prenatal care earlier, follow it more faithfully and receive more continuous care than they otherwise would. It is also possible that women who want to get WIC are less likely to smoke or use illegal drugs in part because they get into care earlier, receive better advice, and are more

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[1] "What is cause for celebration is WIC's extraordinary record of accomplishments for the nutrition and health of the nation's children, and that record has grown as the program has grown." Food Research and Action Center 2005, p. 1. http://www.frac.org/WIC/2004_Report/Summary_Report.pdf.

closely monitored than other similar women. These are important issues that deserve investigation (Bitler and Currie, 2005b).

To help readers assess the debate, the editor of the *Journal of Policy Analysis and Management* (JPAM) invited other researchers to comment on the conflicting conclusions reached by Joyce, Gibson, and Colman (2005) and Bitler and Currie (2005a, 2005b).[2] Ludwig and Miller (2005) noted that the lack of clinical evidence linking nutritional supplementation and preterm birth did not rule out the possibility that the constellation of risk factors addressed by WIC might be protective of preterm birth. Ludwig and Miller (2005) also stressed that both studies had important limitations. First, neither Joyce, Gibson, and Colman (2005) nor Bitler and Currie (2005a) could determine the timing of WIC enrollment. Thus, outcomes that adjusted for the gestational age of infants at delivery would miss any effect of WIC on preterm birth. Second, selection bias remained a potential source of contamination as both studies lacked an exogenous source of variation with which to "randomize" participation into WIC. In New York City, for example, observable risk factors of non-WIC participants improved substantially over the study period, whereas the prevalence of prenatal smoking, illicit drug use, and maternal education fell more modestly among WIC participants (Joyce, Gibson, and Colman 2005).

In this paper, we address several of the issues raised by Bitler and Currie (2005b) and Ludwig and Miller (2005). We use administrative data on WIC linked to birth certificates in North Carolina to examine whether greater exposure to WIC is associated with improved maternal behaviors and birth outcomes. The data are limited to women who enroll in WIC during pregnancy or postpartum. The latter are a potentially compelling comparison group. Postpartum enrollees are obviously eligible for WIC and sufficiently motivated to enroll, and yet were not exposed to WIC during pregnancy. In addition, information on the timing of WIC enrollment allows us to test whether greater access to food vouchers and more opportunities for health education and nutritional counseling decrease smoking, increase weight gain, and improve birth outcomes. Another advantage of the data is that we can more effectively

[2]Ludwig and Miller (2005).

minimize gestational age bias and provide a direct test of the association between WIC and preterm birth (Gordon and Nelson, 1995 Lazariu-Bauer et al., 2004).[3] Finally, we still lack an exogenous source of variation with which to instrument for WIC participation. Nevertheless, we undertake a number of falsification tests in an effort to flag results that may be spurious.

BACKGROUND AND ISSUES

The Special Supplemental Nutrition Program for Women, Infants, and Children was piloted by the U.S. Congress in 1972 and fully authorized in 1974. WIC targets low-income pregnant women, infants, and children up to age five who are at nutritional risk. WIC provides nutritional supplementation through vouchers for specific foods high in protein, calcium, iron, and vitamins A and C. WIC also provides nutritional education and counseling as well as screening and referrals for other health risks such as smoking and substance abuse. Participation in WIC has grown from 88,000 in 1974 to more than 8 million participants in 2006 at a cost of $5.32 billion (www.fns.usda.gov/wic/aboutwic/wicataglance.htm).

Joyce, Gibson, and Colman (2005) provide a recent overview of WIC and its association with improved infant health. Several features of the literature are noteworthy. First, the strongest association between WIC and infant health comes from observational studies based on administrative data, birth certificates, and often a linkage of both (Devaney, Bilheimer, and Schore, 1992; Kotelchuck et al., 1984; Stockbauer, 1987; Schramm, 1985, 1986; Ahluwalia et al., 1998; Buescher and Horton, 2000; Bitler and Currie, 2005). More controlled studies of WIC, prenatal nutritional supplementation, or augmented prenatal care report no or much weaker associations between such programs and birth outcomes (Rush, Stein, and Susser, 1980; Rush et al., 1988; Metcoff, 1985; Klerman et al., 2001).

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[3]The longer a woman carries the pregnancy the greater the opportunity to enroll in WIC. Thus, the association between WIC participation and preterm birth may be spurious if women who might have enrolled in WIC delivered prematurely.

Second, in almost all of the observational studies, the inverse association between WIC and low birth weight is driven by the inverse association between WIC and preterm birth. Most analysts accept this result as plausible despite the lack of clinical support for WIC or other supplemental programs reducing preterm birth (Goldenberg and Rouse, 1998). Indeed, the most recent literature on preterm birth suggests that screening and treatment of vaginal infections may be one of the only effective interventions against preterm birth (Goldenberg, Hauth, and Andrews, 2000; Ugwumadu et al., 2003; Meis et al., 2003; Kiss, Petricevic, and Husslein, 2004). However, this knowledge is too new and results still too inconsistent to explain previous associations between WIC and preterm birth.

Third, the most likely way in which WIC might improve infant health is through improved maternal behaviors leading to increases in fetal growth. Nutritional supplementation, increased vitamin intake, smoking cessation, and the close monitoring of hematocrit levels and hypertension are more likely to operate on fetal growth than on preterm birth (Goldenberg ,1995; Kramer et al., 2000. Despite these possible mechanisms, the association between WIC and proxies of fetal growth is often modest at best (Bitler and Currie, 2005; Gordon and Nelson, 1996; Kotelchuck et al., 1984; Devaney, Bilheimer, and Schore, 1992; Buescher and Horton, 2000; Stockbauer, 1987).

Finally, selection bias remains a potential source of contamination that few observational studies have convincingly confronted. A recent randomized trial of augmented prenatal care suggests that observational studies have overestimated the impact of WIC due to favorable selection among WIC participants (Klerman et al., 2001). In the study, African American women eligible for Medicaid and at risk for adverse birth outcomes were randomized between routine and augmented prenatal care. The latter included specific programs targeted at smoking cessation, weight gain, and vitamin/mineral supplementation. Women in the treatment branch were also given appointment reminders, free transportation, no waiting time for visits, child care, evening office hours, and individualized care with the same practitioner. As a result, women in the treatment group averaged almost two more prenatal visits than women in the routine care group. Despite these documented enhancements, there were no differences in the rate of low birth weight or proportion of births that were small for gestational age (Klerman et al., 2001). The study is important because the bundle of services attempted to address the "constellation of risk factors" that Ludwig and Millar (2005) argue may be lacking from more specifically targeted clinical trials for preterm birth.

EMPIRICAL IMPLEMENTATION

Data

Our data are from the Pregnancy Nutritional Surveillance System (PNSS) in North Carolina. The PNSS is ". . . a program-based surveillance system that monitors the nutritional status of low-income infants, children, and women in federally funded maternal and child health programs" (http://www.cdc.gov/pednss/). The PNSS collects information from WIC Program participants at the points of prenatal and postpartum enrollment. At the prenatal interview, WIC interviewers collect demographic information, as well indicators of maternal health and behavior. At the postpartum visit, information on infant health and postpartum behaviors is added. Twenty-two states currently participate in PNSS.

The PNSS in North Carolina includes all women who enrolled in WIC either during pregnancy or postpartum, who were residents of North Carolina, and who gave birth between 1996 and 2003. We have information on 424,699 women who had singleton births over the study period. A significant advantage of the North Carolina program is that the PNSS data are linked to birth certificates each year. This augments the data collected by PNSS for items such as smoking, prenatal care, and weight gain during pregnancy. The linkage also provides more detailed information on birth outcomes such as gestational age.

Econometric Issues

We begin the multivariate analysis with regressions of the following form:

$$H = \alpha_0 + \alpha_1 \text{WIC} + \mathbf{X\beta} + e \qquad (1)$$

Let H be a health outcome such as birth weight and let WIC be a dichotomous indicator of whether the women enrolled in WIC during pregnancy. The omitted category is women who enroll in WIC postpartum, approximately 16 percent of the sample. Let **X** be a matrix of other relevant variables, including demographic and socioeconomic characteristics. We expect that women who enroll during pregnancy have healthier infants than those who enroll after delivery (i.e., $\alpha_1 > 0$ for favorable outcomes and $\alpha_1 < 0$ for adverse outcomes). We estimate Equation (1) by ordinary least squares when the dependent variable is continuous and by maximum likelihood probit in the case of dichotomous outcomes.

Equation (1) is the most common specification in the literature (see Joyce, Gibson, and Colman, 2005; and Bitler and Currie, 2005, for recent examples). The coefficient on WIC, α_1, estimates the average effect of treatment on the treated (TOT) under two assumptions: first, that the decision to participate in WIC, conditional on **X,** is uncorrelated with infant health in the absence of participation; and second, that the expected gains to participation are constant across individuals (Heckman, 1997; Wooldridge, 2002).[4] These are clearly strong assumptions, yet we know of no study that has been able to credibly instrument for WIC participation. One fallback strategy has been to include a rich set of controls to lessen omitted variable bias (Gordon and Nelson, 1995; Bitler and Currie, 2005). Others have used propensity score matching as a means of balancing observable characteristics between WIC and non-WIC participants (Lazariu-Bauer et al., 2004).

We also try to minimize selection bias by focusing on the quality of the comparison group and use our large sample size to enrich the specification. For instance, we use women who enrolled in WIC postpartum to identify the prenatal effects of WIC on maternal behavior and birth outcomes. One advantage of our comparison group is that everyone is eligible for WIC and everyone participates. Thus,

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[4]The term "average treatment effects" connotes estimates from a randomized trial. However, as noted by Wooldridge (2002), "Broadly, most estimators of ATEs [*average treatment effects*] fit into two categories. The first set exploits assumptions concerning ignorability of the treatment conditional on a set of covariates…and in some cases reduces to an OLS regression with many controls" (Wooldridge p. 603). We use average treatment effects in this manner. Note also that stratification by race, ethnicity, nativity, parity, and prenatal care is equivalent to a pooled model with a large set of interactions between these characteristics and each of the variables in **X** of equation (1).

the stigma associated with participation in publicly funded nutrition programs that may keep some women from participating in WIC is unlikely to be a factor in our analysis. Second, precise dates of enrollment from administrative data let us estimate timing of WIC participation. Bitler and Currie (2005) and Joyce, Gibson, and Colman (2005) relied on maternal self-reports of WIC participation and had no information on the length of enrollment. Third, we have a very large sample that enables us to stratify the analysis by race and ethnicity. We thus estimate separate models for non-Hispanic whites, non-Hispanic blacks, and Hispanics. This considerably enhances the specification. The standard regression in the literature pools all races and ethnicities and includes dichotomous indicators for each. Our specification is equivalent to a fully interacted model by race and ethnicity. The difference is important because treatment effects can vary dramatically by race and ethnicity (Joyce, Gibson, and Colman, 2005).[5]

With data on the timing of WIC enrollment we can also refine the specification in equation (1) as follows:

$$(2) \qquad H = \alpha_0 + \alpha_1 WIC\_1 + \alpha_2 WIC\_2 + \alpha_3 WIC\_3 + \mathbf{X\beta} + e$$

The WIC indicators designate the trimester of pregnancy when a woman enrolled in WIC. The omitted category is again postpartum enrollment. If greater exposure to WIC improves infant health and increases healthy behavior, we would expect to find that $\alpha_1 > \alpha_2 > \alpha_3$. One advantage of Equation (2) is that we can more effectively correct for gestational age bias. A common concern in studies of WIC is that women whose pregnancies are longer have a greater opportunity to enroll. Thus, α_3 in Equation (2) may be positive and significant because of the underlying health of the fetus, and not the treatment effects associated with WIC. Enrollment in WIC may also be confounded with enrollment in prenatal care. Women who initiate prenatal care late or who receive no care at all are likely to be disproportionately distributed among the non-WIC participants. Although many researchers control for prenatal care, late or

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[5]One interpretation of the racial differences is treatment heterogeneity. However, others have interpreted racial differences as further evidence of omitted variable bias (Joyce, Gibson, and Colman, 2005). The authors note that differences in treatment effects by race and ethnicity were limited to preterm birth. WIC was unassociated with fetal growth among any racial or ethnic group. As noted above, there is little support in the clinical literature for an association between nutritional supplementation and preterm birth.

no prenatal care may be associated with hard-to-measure inputs such as substance abuse and other risky behaviors. To limit this source of bias, we will also estimate Equation (2) for the subset of women who initiate prenatal care in the first trimester and who have no previous live births. In other words, we will analyze whether variation in the timing of WIC enrollment among women who begin prenatal care early and who have no prior experience with WIC improves infant health. These estimates are unlikely to generalize to the population of all WIC participants, but they may provide less contaminated estimates for a relatively large group of WIC enrollees.

Our approach to this point has been to try to limit potential contamination from selection bias. One difficulty is the lack of results from clinical trials of WIC with which to benchmark our estimates.[6] However, there have been many clinical trials of preterm birth, smoking cessation programs, and a few trials of nutritional supplementation. These provide some guidance for our estimates (Collaborative Group on Preterm Birth Prevention, 1993; Dyson et al., 1998; Sexton and Hebel, 1984; Secker-Walker et al., 1995; Windsor et al., 1993; Rush, Stein and Susser, 1980). In addition, data on the timing of WIC enrollment allow additional falsification checks. For instance, Bitler and Currie (2005b) argue that WIC may work by increasing the likelihood of early or adequate prenatal care. We can test for such associations by analyzing whether women who initiate prenatal care in the first trimester obtain more prenatal care if enrolled in WIC earlier rather than later.

Bitler and Currie (2005b) have also argued that WIC may increase the likelihood that a woman stops or limits her smoking. If true, then WIC enrollment must precede changes in smoking. We can explicitly test this with the PNSS. At WIC enrollment, women are asked if they smoke, and if so, whether and when they quit. One response is, “Stopped smoking after becoming pregnant” (see Appendix). The clinical literature indicates that most pregnant smokers quit at this moment, which is sometimes referred to as “spontaneous quitting” (Quinn, Mullen and Ershoff, 1991; Sexton and Hebel, 1984; Secker-Walker

[6] The one trial that exists is unlikely to generalize to current conditions; it had limited power, was localized to one clinic, and is over 20 years old (Metcoff et al., 1985).

et al., 1995; Windsor et al., 1993). Thus, we regress our measure of spontaneous quitting on WIC. Any association between WIC participation or the timing of WIC participation and spontaneous quitting is likely spurious since quitting preceded enrollment.

Finally, we will also analyze maternal weight gain during pregnancy. As with preterm birth, greater exposure to WIC should be associated with greater weight gain (i.e., $\alpha_1 > \alpha_2 > \alpha_3$ from Equation 2). A finding that $\alpha_3 > \alpha_1$ would be suspect and suggestive of gestational age bias.

In sum, our ability to correct for selection bias may be limited. However, we will use a series of specification and falsification checks as a means of flagging potential contamination from omitted variable bias.

RESULTS

Prenatal versus Postpartum Enrollees

Summary characteristics of prenatal and postpartum WIC participants are shown in Table 1. Women who do not enroll in WIC until postpartum are more likely to be older, married, of higher parity, to have more completed schooling, and are less likely to receive Medicaid, welfare, and food stamps relative to women who enrolled in WIC during pregnancy. Comparisons of birth outcomes and maternal behaviors between prenatal and postpartum WIC participants is shown in Table 2. Differences are substantial and appear driven by disparities in preterm birth. For example, prenatal enrollment in WIC is associated with a decrease in preterm birth of 4.6 percentage points, adjusted for maternal characteristics. However, differences in proxies for fetal growth—birth weight adjusted for gestational age, infant small for gestational age (SGA), and term low birth weight—are clinically small, though statistically significant. Prenatal WIC enrollment is associated with an increase of 12.5 grams in birth weight adjusted for gestation and declines of 0.3 and 0.2 percentage points in SGA and term low birth weight, respectively.

Table 1
Characteristics of Women by Timing of WIC Enrollment:
Prenatal vs. Postpartum, North Carolina Singleton Births, 1996–2003

	Prenatal WIC	Postpartum WIC	Diff.
Race/Ethnicity			
Non-Hispanic White	0.450	0.484	-0.034*
Non-Hispanic Black	0.381	0.349	0.032*
Native American	0.024	0.024	0.000
Asian	0.014	0.020	-0.005*
Hispanic	0.130	0.123	0.007*
Other/Unknown	0.000	0.000	0.000**
Marital Status			
Married	0.432	0.538	-0.106*
Unknown	0.0014	0.0002	0.0012*
Parity			
0	0.447	0.353	0.093*
1–3	0.520	0.603	-0.083*
4+	0.034	0.044	-0.010*
Age			
Under 18 years	0.093	0.051	0.042*
18–24	0.542	0.491	0.051*
25–29	0.216	0.263	-0.048*
30–35	0.115	0.147	-0.032*
Over 35 years	0.036	0.049	-0.013*
Education Level (Mothers ≥ 25 years)			
<12 years	0.238	0.181	0.057*
12 years	0.423	0.397	0.026*
>12 years	0.337	0.420	-0.084*
Unknown	0.002	0.002	0.000
Mean Pregravid Weight (lbs)	153.720	153.629	0.091
Unknown Pregravid Weight	0.021	0.114	-0.093*
Medicaid	0.774	0.576	0.198*
AFDC/TANF	0.096	0.076	0.020*
Food Stamps	0.190	0.132	0.058*
Female Infant	0.489	0.484	0.005*
Lost to follow-up[a]	0.139		
N	342,989	64,296	

* p<.01, ** p<.05.
[a]Proportion of prenatal enrollees who did not return for a WIC postpartum visit.

Table 2
Adjusted and Unadjusted Birth Outcomes and Maternal Behaviors by Timing of WIC Enrollment: Prenatal vs. Postpartum, North Carolina Singleton Births, 1996–2003

	Prenatal WIC	Postpartum WIC	Unadjusted Difference	Adjusted Difference
Birth Outcomes				
Birth weight (grams)	3,252	3,202	49.1*	78.8*
Low birth weight (LBW)	0.083	0.111	-0.028*	-0.034*
Preterm	0.095	0.139	-0.044*	-0.046*
Birth weight |gestation	N/A	N/A	N/A	12.488*
Small for gestational age	0.132	0.123	0.010*	-0.003***
Term LBW	0.028	0.028	0.000	-0.002*
Behaviors				
Trimester of prenatal care				
First trimester	0.779	0.743	0.035*	0.052*
Second trimester	0.188	0.180	0.008*	-0.007*
Third trimester	0.028	0.043	-0.016*	-0.015*
No care	0.003	0.030	-0.027*	-0.019*
Unknown	0.003	0.004	-0.001**	-0.0004***
Number of prenatal visits	12.2	11.5	0.7*	0.7*
Smoked before pregnancy	0.397	0.301	0.097*	0.087*
Smoked during pregnancy	0.307	0.204	0.103*	0.098*
Smoked during pregnancy+	0.209	0.204	0.005*	-0.008*
Stopped smoking when discovered pregnant#	0.097			
Smoked postpartum¶	0.180	0.182	-0.001	-0.022*
Stopped smoking when discovered pregnant¶	0.078	0.055	0.022*	0.016*
Maternal weight gain (lbs)	30.0	28.6	1.3*	0.873*
N	342,989	64,296		

* p<.01, ** p<.05; + from birth certificates; # prenatal WIC enrollees only; ¶ postpartum question only. Adjusted differences are from regressions of each outcome on the set of maternal characteristics shown in Table 1. Continuous outcomes are estimates by ordinary least squares and dichotomous outcomes by maximum likelihood probit.

Differences in maternal behavior do not suggest obvious explanations for the differences in preterm birth. Women who enrolled in WIC postpartum are more likely to have no prenatal care or to have started it in the third trimester. Prenatal enrollees also gain about one pound more during pregnancy, adjusted for maternal characteristics, than do postpartum enrollees. However, there is little difference in smoking between the two groups when we restrict the screen for smoking to questions that are consistently asked of both prenatal and postpartum enrollees. For instance, if we use the birth certificate screen which asks, “Did you smoke during pregnancy?” we find that 20.9 percent of prenatal enrollees said yes compared with 20.4 percent among postpartum enrollees. Similarly, both prenatal and postpartum women are asked about their change in smoking during pregnancy at the postpartum interview. Again, we find no differences in the prevalence of smoking (18.0 versus 18.2).

The pattern of results in Table 2 is similar to that of Joyce, Gibson, and Colman (2005) and Bitler and Currie (2005a). It is also consistent with earlier studies of WIC (Devaney et al., 1992; Gordon and Nelson, 1995). In each study, researchers reported substantial differences in preterm birth between WIC and non-WIC enrollees but modest or no differences in proxies of fetal growth. However, only Joyce, Gibson, and Colman (2005) analyzed differences by race and ethnicity. Importantly, they found that differences in preterm birth associated with WIC were restricted to US-born non-Hispanic blacks. In Table 3 we further break down differences between prenatal and postpartum WIC enrollees by non-Hispanic whites, non-Hispanic blacks, and Hispanics. The basic finding with respect to birth outcomes reported for all women in Table 2 persists within race and ethnicity. There are large differences in preterm birth but no or modest differences in fetal growth. The differences in preterm birth between prenatal and postpartum WIC enrollees among non-Hispanic blacks are greatest in both absolute (-6.2 percentage points) and relative terms (54 percent).

Differences in smoking vary substantially by race and ethnicity (Table 3). We find that 56.1 percent of non-Hispanic whites who signed up prenatally smoked three months before pregnancy compared with 28.9 percent among non-Hispanic blacks and 15.8 percent among Hispanics. If we only

Table 3
Adjusted and Unadjusted Differences in Birth Outcomes and Maternal Behaviors by Race/Ethnicity and Timing of WIC Enrollment: Prenatal vs. Postpartum, North Carolina Singleton Births, 1996–2003

	Non-Hispanic White				Non-Hispanic Black				Hispanic			
	Prenatal WIC	Postpartum WIC	Unadjusted Difference	Adjusted Difference	Prenatal WIC	Postpartum WIC	Unadjusted Difference	Adjusted Difference	Prenatal WIC	Postpartum WIC	Unadjusted Difference	Adjusted Difference
Birth Outcomes												
Birth weight (grams)	3,322.5	3,281.5	41.1*	78.5*	3135.8	3061.6	74.1*	92.4*	3350.4	3291.9	58.5*	62.9*
Low birth weight (LBW)	0.070	0.094	-0.024*	-0.032*	0.112	0.153	-0.042*	-0.045*	0.047167	0.063	-0.016*	-0.015*
Preterm	0.087	0.124	-0.037*	-0.041*	0.115	0.178	-0.064*	-0.062*	0.064196	0.093	-0.029*	-0.026*
Birth weight || gestation				16.147*				7.818**				18.922*
Small for gestational age	0.112	0.105	0.007*	-0.005*	0.167	0.151	0.016*	0.004*	0.098165	0.106	-0.008**	-0.010*
Term LBW	0.025	0.024	0.001	-0.002**	0.036	0.036	0.000	-0.003***	0.016648	0.019	-0.002	-0.002
Behaviors												
Trimester of prenatal care												
First trimester	0.834	0.828	0.006*	0.028*	0.747	0.653	0.095*	0.101*	0.693	0.678	0.015*	0.025
Second trimester	0.144	0.129	0.015*	-0.003	0.214	0.230	-0.016*	-0.024*	0.251	0.228	0.023*	0.023*
Third trimester	0.017	0.024	-0.007*	-0.009*	0.032	0.062	-0.030*	-0.026*	0.050	0.067	-0.017*	-0.013*
No care	0.002	0.016	-0.014*	-0.011*	0.003	0.052	-0.049*	-0.034*	0.004	0.024	-0.021*	-0.013*
Unknown	0.003	0.003	-0.001	-0.001***	0.003	0.004	-0.001*	-0.0004	0.004	0.004	0.000	-0.0001
Number of prenatal visits	12.75	12.40	0.348*	0.464*	12.0	10.7	1.301*	1.25*	11.00	10.59	0.410*	0.265*
Smoked before pregnancy	0.561	0.416	0.144*	0.096*	0.289377	0.220	0.069*	0.067*	0.157454	0.088	0.070*	0.059*
Smoked during pregnancy	0.444	0.296	0.147*	0.109*	0.214963	0.141	0.074*	0.078*	0.107598	0.026	0.081*	0.077*
Smoked during pregnancy+	0.340	0.296	0.043*	0.001*	0.119927	0.141	-0.021*	-0.017*	0.024227	0.026	-0.002	-0.007*
Stopped smoking when discovered pregnant#	0.145				0.065				0.029			
Smoked postpartum¶	0.282	0.254	0.028*	-0.023*	0.108472	0.126	-0.018*	-0.022*	0.04975	0.061	0.007*	-0.018*
Stopped smoking when discovered pregnant¶	0.119	0.080	0.039*	0.029*	0.051256	0.039	0.012*	0.008*	0.021627	0.015	0.000*	0.003***
Maternal weight gain (lbs)	31.98	30.56	1.42*	0.91*	28.76	27.12			26.78	25.74	1.043*	0.518*
N	154,418	31,112			130,646	22,455			44,629	7,923		

We used maternal characteristics in Table 1 to obtain adjusted estimates. Adjusted differences in dichotomous outcomes are marginal effects from maximum likelihood probits.
[a] Excludes prenatal enrollees who did not return for a WIC postpartum visit. #prenatal WIC enrollees only; + birth certificates only; ¶ postpartum questions only; * p<.01, ** p<.05, ***p<.10.

use the indicator of smoking during pregnancy reported on birth certificates, we find no differences between prenatal and postpartum WIC enrollees who are non-Hispanic white, but modestly less smoking among non-Hispanic black and Hispanic prenatal enrollees.

Maternal Characteristics by Trimester Of Enrollment

Table 4 shows maternal characteristics by trimester of WIC enrollment. Differences by parity are substantial. Among women with no previous live births, 48.5 percent enroll in the first trimester, 43.7 percent in the second, 39.4 percent in the third, and 35.3 percent postpartum. Schooling is also associated with greater delay in WIC enrollment. Almost 32 percent of women 25 years or older who enroll in WIC in the first trimester have more than 12 years of schooling compared with 42 percent of women who enroll postpartum. The relationship between early WIC enrollment and participation in other publicly funded programs has a similar gradient. Those most likely to be on Medicaid, welfare, and to receive food stamps are also the most likely to enroll in the first trimester. Based on these observed characteristics, early enrollees in WIC appear adversely selected.

Birth Outcomes by Trimester of Enrollment

We display adjusted differences in birth outcomes by trimester of WIC enrollment in Table 5. The first column pertains to all women and the other three are by specific race/ethnicity. The largest differences in birth weight, low birth weight, and preterm birth occur between third-trimester and postpartum participants. The most dramatic difference occurs for preterm birth. For instance, non-Hispanic blacks who enroll in WIC in the third trimester are 8.3 percentage points less likely to experience a preterm birth relative to postpartum women. More generally, the later in pregnancy a women enrolls in WIC, the greater the protective effect against preterm birth. The results are counterintuitive since we expect greater exposure to WIC to be associated with greater benefits. Compared with earlier participants, third-trimester women are more similar to postpartum women in terms of parity, education, and public program participation. Finally, there is little evidence in the clinical literature to support such

Table 4
Characteristics of Women by Trimester of WIC Enrollment, North Carolina Singleton Births, 1996–2003

	First Trimester (WIC1)	Second Trimester (WIC2)	Third Trimester (WIC3)	Postpartum (WIC4)	WIC1-WIC3
Race/Ethnicity					
Non-Hispanic White	0.517	0.405	0.412	0.484	0.105*
Non-Hispanic Black	0.342	0.406	0.405	0.349	-0.063*
Native American	0.025	0.025	0.020	0.024	0.005*
Asian	0.009	0.017	0.019	0.020	-0.009*
Hispanic	0.106	0.146	0.144	0.123	-0.038*
Other/Unknown	0.000	0.000	0.001	0.000	0.000
Marital Status					
Married	0.452	0.412	0.435	0.538	0.017*
Unknown	0.002	0.002	0.001	0.000	0.001*
Parity					
0	0.485	0.437	0.394	0.353	0.091*
1–3	0.488	0.526	0.567	0.603	-0.079*
4+	0.027	0.037	0.039	0.044	-0.012*
Age					
Under 18 years	0.090	0.100	0.084	0.051	0.006*
18–24	0.551	0.534	0.538	0.491	0.013*
25–29	0.214	0.213	0.223	0.263	-0.009*
30–35	0.112	0.115	0.118	0.147	-0.006*
Over 35 years	0.033	0.038	0.037	0.049	-0.004*
Education Level (Mothers 25 ≥ years)					
<12 years	0.244	0.246	0.214	0.181	0.030*
12 years	0.436	0.415	0.415	0.397	0.021*
>12 years	0.319	0.337	0.369	0.420	-0.050*
Unknown	0.002	0.002	0.002	0.002	0.000
Mean Pregravid Weight (lbs)	157	152	151	154	5*
Unknown Pregravid Weight	0.020	0.021	0.024	0.114	-0.004*
Medicaid	0.819	0.769	0.699	0.576	0.120*
AFDC/TANF	0.092	0.101	0.095	0.076	-0.003***
Food Stamps	0.199	0.190	0.174	0.132	0.025*
Female Infant	0.494	0.485	0.489	0.484	0.004***
Lost to follow-up[a]	0.124	0.143	0.157		-0.033*
N	133,430	137,373	72,186	64,296	

* p<.01, ** p<.05, ***p<.10.
[a] Proportion of prenatal enrollees who did not return for a WIC postpartum visit.

Table 5
Adjusted Differences in Birth Outcomes by Race/Ethnicity and Trimester of WIC Enrollment, North Carolina Singleton Births, 1996–2003

	All Women	Non-Hispanic White	Non-Hispanic Black	Hispanic
Birth weight (grams)				
First-trimester WIC	60.7*	64.6*	64.7*	55.2*
Second-trimester WIC	68.2*	70.0*	75.7*	57.5*
Third-trimester WIC	126.6*	119.2*	156.3*	83.0*
Low birth weight (LBW)				
First-trimester WIC	-0.022*	-0.022*	-0.027*	-0.010*
Second-trimester WIC	-0.023*	-0.022*	-0.031*	-0.010*
Third-trimester WIC	-0.049*	-0.043*	-0.068*	-0.025*
Preterm				
First-trimester WIC	-0.028*	-0.027*	-0.036*	-0.016*
Second-trimester WIC	-0.034*	-0.029*	-0.045*	-0.020*
Third-trimester WIC	-0.063*	-0.058*	-0.083*	-0.037*
Birth weight|gestation				
First-trimester WIC	22.0*	22.5*	19.4*	34.4*
Second-trimester WIC	9.9*	13.9*	5.1	18.2
Third-trimester WIC	1.1	7.6**	-2.9	-0.3
Small for gestational age				
First-trimester WIC	-0.004*	-0.005**	0.001	-0.013*
Second-trimester WIC	-0.002	-0.006*	0.005	-0.012*
Third-trimester WIC	-0.0001	-0.005**	0.006***	-0.001
Term low birth weight				
First-trimester WIC	-0.003*	-0.002***	-0.003**	-0.003***
Second-trimester WIC	-0.002**	-0.001	-0.002	-0.002
Third-trimester WIC	-0.004*	-0.003*	-0.003**	-0.003
N	407,285	185,530	153,101	52,552

See notes to Table 2. *p<.01, **p<.05, ***p<.10.

large differences in preterm birth driven by women least exposed to a beneficial treatment. In sum, the large differences in preterm birth rates are simply not credible and are strongly suggestive of gestational age bias.

More evidence of gestational age bias is revealed when we examine proxies for fetal growth. Generally, prenatal enrollment in WIC is associated with better birth outcomes. For all women, first trimester WIC enrollment is associated with an increase of 22.1 grams in birth weight adjusted for gestation, a decline in the incidence of SGA of 0.4 percentage points, and a fall in term low birth weight of 0.3 percentage points. This general pattern persists across race and ethnicity. Thus, results for fetal growth, in which gestational age bias is not an issue, are more consistent with the expectation that greater exposure to WIC should be associated with improved outcomes. However, the gains are modest clinically and there is virtually no difference in SGA and term low birth weight between first and third-trimester enrollees.

<u>Maternal Behaviors by Trimester of WIC Enrollment</u>

Table 6 shows differences in smoking and maternal weight gain by trimester of WIC enrollment for all women and by race and ethnicity. If we limit comparisons to prenatal WIC enrollees, we find that first-trimester participants are slightly more likely to have smoked prior to pregnancy than women who enrolled in the third trimester (1.4 percentage points) or second trimester (2.3 percentage points). This pattern persists for non-Hispanic whites and non-Hispanic blacks, but not Hispanics. Differences in smoking during pregnancy are also modest and only among Hispanics do we find meaningful differences in smoking between first-trimester and third-trimester enrollees (-1.9 percentage points).

If we use the birth certificate screen for smoking, we are able to compare prenatal and postpartum participants. Generally, prenatal enrollees are slightly less likely to smoke during pregnancy than women who enroll postpartum. The differences are not large nor consistent with the expectation that greater exposure to WIC leads to less smoking. Those who enroll in WIC in the second trimester, for instance, are the least likely to smoke.

Table 6
Adjusted Differences in Maternal Behaviors by Race/Ethnicity and Trimester of WIC Enrollment, North Carolina Singleton Births, 1996–2003

	All Women	Non-Hispanic White	Non-Hispanic Black	Hispanic
Smoked before pregnancy#				
First-trimester WIC	0.014*	0.024*	0.009*	-0.017*
Second-trimester WIC	-0.009*	-0.001	-0.008**	-0.017*
Smoked during pregnancy#				
First-trimester WIC	0.004***	0.021*	-0.009*	-0.019*
Second-trimester WIC	-0.011*	-0.004	-0.013*	-0.014*
Smoked during pregnancy+				
First-trimester WIC	-0.006*	0.004	-0.016*	-0.004**
Second-trimester WIC	-0.013*	-0.006***	-0.019*	-0.007*
Third-trimester WIC	-0.003	0.009**	-0.010*	-0.007*
Stopped smoking when discovered pregnant#				
First-trimester WIC	0.012*	0.007*	0.020*	0.006*
Second-trimester WIC	0.002	0.002	0.003***	0.001
Smoked postpartum¶				
First-trimester WIC	-0.015*	-0.015*	-0.019*	-0.016*
Second-trimester WIC	-0.027*	-0.032*	-0.024*	-0.018*
Third-trimester WIC	-0.019*	-0.024*	-0.017*	-0.012*
Stopped smoking when discovered pregnant¶				
First-trimester WIC	0.025*	0.040*	0.017*	0.006*
Second-trimester WIC	0.015*	0.030*	0.006*	0.002
Third-trimester WIC	0.009*	0.020*	-0.0003*	0.001
Maternal weight gain				
First-trimester WIC	0.944*	0.841*	1.025*	1.156*
Second-trimester WIC	0.913*	1.072*	1.046*	0.494*
Third-trimester WIC	0.687*	0.792*	0.954*	-0.271
N	407,285	185,530	153,101	52,552

See notes to Table 2. *p<.01; **p<.05.
prenatal WIC enrollees only; omitted category is third trimester enrollees; + birth certificates only; omitted category is postpartum enrollees; ¶ postpartum questions only; omitted category is postpartum enrollees * p<.01,** p<.05,***p<.10.

There are more substantial differences in postpartum smoking between prenatal and postpartum WIC enrollees. Women who enroll in WIC during pregnancy are less likely to smoke when asked postpartum than are women who enrolled in WIC after delivery. As before, the biggest differences occur for second-trimester enrollees. This is true across race and ethnicity. Another question that is asked consistently of all women in the postpartum interview is whether they stopped smoking when they were pregnant (spontaneous quitters). For this outcome we find that the earlier a woman enrolled in WIC, the more likely she was to spontaneously quit. Specifically, quit rates are 2.5 percentage points greater for first-trimester relative to postpartum enrollees.[7] Among race/ethnic groups, differences are greatest among non-Hispanic whites (4.0 percentage points) and least likely among Hispanics (0.6 percentage points).

The last outcome is maternal weight gain during pregnancy. The difference between prenatal and postpartum WIC enrollees is slightly less than one pound. The weight gain disparities between first- and third-trimester participants are smaller, except among Hispanics.

Selection and Falsification

We have two concerns with the results so far. First, we have not adequately disentangled the effects of WIC from the potential effects of prenatal care. Indeed, Bitler and Currie (2005b) argue that WIC may improve birth outcomes by enhancing compliance with prenatal care. Thus, controlling for both prenatal care and for timing of WIC enrollment may underestimate WIC's total effect on maternal behaviors and infant health.

Second, we have no means to convincingly instrument for WIC participation as a possible correction for selection bias. We attempt to address these issues in the next set of analyses. Here we limit the sample to women who initiate prenatal care in the first trimester and who have no previous live births. Women who initiate prenatal care in the first trimester may have stronger preferences for a healthy

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[7]We define the spontaneous quit rate as number of women who stopped smoking when they became pregnant over all women, smokers and nonsmokers. The mean is 7.3 percent.

outcome or be more risk averse than women who initiate prenatal care later. By limiting the sample to first births, we eliminate women who may have experience with WIC from a previous pregnancy or whose child may already be enrolled in WIC.[8] We then re-estimate the birth outcome and maternal behavior regressions. One objective is to exploit variation in WIC exposure among a relatively homogenous group of participants. The other is to flag associations that should not be attributable to WIC.

The results for birth outcomes are displayed in Table 7. The pattern is very similar to results in Table 5. There is strong evidence of gestational age bias because third-trimester enrollment in WIC has the strongest association with preterm birth. The adjusted difference in preterm birth between third-trimester and postpartum enrollees is again huge, 6.7 percentage points. There are small and clinically unimportant differences in preterm birth between first and second-trimester WIC enrollees. As before, the association between WIC and fetal growth is modest and often lacks statistical significance. If we compare differences in fetal growth among women who enroll in WIC during pregnancy, there are no meaningful differences. Thus, findings for birth outcomes are consistent with the clinical literature: Few interventions appear protective against preterm birth, and the association between nutritional supplementation and fetal growth in developed countries is generally modest.

Despite the clinical evidence, Ludwig and Miller (2005) speculate that WIC's multifaceted approach to nutrition, prenatal care, and health education might explain the strong protective effect of WIC against preterm birth reported by Bitler and Currie (2005a). Thus, the next set of results in Table 8 tests whether earlier WIC enrollment is associated with more prenatal care, less smoking, and greater weight gain among our subsample of first-time mothers and early prenatal care initiators.

We start with prenatal care. Women who begin both prenatal care and WIC in the first trimester obtain between -0.11 (Hispanics) to 0.37 more prenatal care visits (non-Hispanic blacks) than women

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[8]Gordon and Nelson (1995) estimated that 66.8 of prenatal WIC participants were enrolled in WIC during a prior pregnancy.

Table 7
Adjusted Differences in Birth Outcomes by Race/Ethnicity and Trimester of WIC Enrollment Among Women Who Began Prenatal Care in the First Trimester and With No Previous Live Births: North Carolina Singleton Births, 1996–2003±

	All Women	Non-Hispanic White	Non-Hispanic Black	Hispanic
Birth weight (grams)				
First-trimester WIC	57*	55*	76*	49*
Second-trimester WIC	68*	69*	82*	48*
Third-trimester WIC	141*	135*	187*	77*
Low birth weight (LBW)				
First-trimester WIC	-0.025*	-0.023*	-0.034*	-0.017*
Second-trimester WIC	-0.026*	-0.024*	-0.035*	-0.015*
Third-trimester WIC	-0.055*	-0.048*	-0.057*	-0.034*
Preterm				
First-trimester WIC	-0.028*	-0.028*	-0.036*	-0.014**
Second-trimester WIC	-0.032*	-0.029*	-0.042*	-0.018*
Third-trimester WIC	-0.067*	-0.063*	-0.084*	-0.042*
Birth weight|gestation				
First-trimester WIC	11.8*	7.1	17.5**	13.6
Second-trimester WIC	6.3	10.1***	2.3	3.7
Third-trimester WIC	5.4	11.0***	3.2	-13.4
Small for gestational age				
First-trimester WIC	-0.003	-0.002	0.002	-0.016***
Second-trimester WIC	-0.003	-0.005	0.006	-0.019**
Third-trimester WIC	-0.002	-0.002	0.003	-0.005
Term low birth weight				
First-trimester WIC	-0.002	-0.0004	-0.004	-0.005
Second-trimester WIC	-0.001	-0.001	-0.002	-0.001
Third-trimester WIC	-0.002	-0.001	-0.004	-0.003
N	139,544	71,677	47,854	14,890

±See notes to Table 2. The omitted category is women who enrolled in WIC postpartum. *p<.01, **p<.05.

Table 8
Specification Checks of Maternal Behaviors Among Women Who Begin Prenatal Care in the First Trimester and Who Have No Previous Live Births: North Carolina Singleton Births, 1996–2003±

	All Women	Non-Hispanic White	Non-Hispanic Black	Hispanic
Prenatal Care				
Number of visits				
First-trimester WIC	0.245*	0.219*	0.367*	-0.106
Second-trimester WIC	-0.06**	-0.034	0.016	-0.413*
Third-trimester WIC	0.097*	0.161*	0.134***	-0.336*
Prenatal Care|Gestation				
Number of visits				
First-trimester WIC	0.15*	0.121*	0.238*	-0.182*
Second-trimester WIC	-0.189*	-0.154*	-0.161*	-0.505**
Third-trimester WIC	-0.187*	-0.089***	-0.273*	-0.526*
Smoking				
Stopped smoking when discovered pregnant#				
First-trimester WIC	0.011*	0.005	0.024*	-0.002
Second-trimester WIC	0.002	0.005	0.004	-0.004
Stopped smoking when discovered pregnant¶				
First-trimester WIC	0.042*	0.062*	0.017*	0.012**
Second-trimester WIC	0.030*	0.053*	0.004	0.006
Third-trimester WIC	0.024*	0.045*	-0.004	0.002
Weight Gain				
Maternal weight gain				
First-trimester WIC	0.758*	0.751*	0.473***	1.005*
Second-trimester WIC	0.851*	1.079*	0.623**	0.175
Third-trimester WIC	0.910*	0.925*	0.887*	0.507
Weight Gain|Gestation				
Maternal weight gain				
First-trimester WIC	0.473*	0.445*	0.114*	0.796**
Second-trimester WIC	0.469*	0.705*	0.133	-0.080
Third-trimester WIC	0.070	0.142*	-0.239	-0.017
N	139,544	71,677	47,854	14,890

±See notes to Table 2. The omitted category is women who enrolled in WIC postpartum except when the sample is limited to prenatal enrollees only.
prenatal WIC enrollees only; ¶ postpartum questions only; * p<.01,** p<.05, ***p<.10.

who initiate prenatal care early but who do not enroll in WIC until postpartum. Given a mean of approximately 13 visits per pregnancy, these are modest gains. If we adjust prenatal care visits for the length of the pregnancy, the results change inconsequentially.

We next ask whether there is any association between the timing of WIC enrollment and women who quit smoking *when they become pregnant.* As noted above, we refer to these women as spontaneous quitters. We contend that an association between the timing of WIC enrollment and spontaneous quitting is likely spurious. We focus on first births to women who initiate prenatal care in the first trimester in order to minimize differences in the time until pregnancy recognition as well as anti-smoking advice from previous pregnancy. The results are shown in Table 8. Among prenatal participants, we find that those who enroll in the first trimester are 1.1 percentage points more likely to spontaneously quit smoking relative to third-trimester enrollees. The largest difference occurs among non-Hispanic blacks (2.4 percentage points). These differences are substantial, given that 9.7 percent of all prenatal WIC enrollees are spontaneous quitters. Differences in spontaneous quitting by trimester of WIC enrollment become more pronounced when the question is asked of all women at the postpartum interview. First-trimester participants are 4.2 percentage points more likely to quit when they become pregnant relative to postpartum WIC enrollees (mean = 7.8 percent). Spontaneous quitting declines with later enrollment in WIC, a pattern that persists across race and ethnicity.

The third outcome of interest is maternal weight gain during pregnancy. We show results with and without adjustments for the length of pregnancy. In specifications without controls for gestational age, we see that women who enroll in WIC postpartum, despite early initiation of prenatal care, gain almost one pound less during pregnancy than women who enroll in WIC prenatally. These are similar to the results in Table 6 that use all women, regardless of when they initiate prenatal care. Moreover, there is little difference in weight gain among the prenatal WIC enrollees. However, when we control for gestational age, differences in weight gain are reduced by approximately half. There are also no meaningful differences between third-trimester and postpartum WIC enrollees. Thus, the similarity or slight advantage in weight gain observed among third relative to first-trimester WIC enrollees is due to the longer gestations of third-trimester enrollees.

The results in Tables 7 and 8 offer several insights. First they reinforce the importance of gestational age bias. Even when we limit the sample to early initiators of prenatal care, third-trimester WIC enrollees have lower rates of preterm and low-birth-weight birth than any other group of WIC enrollees. Yet third-trimester WIC enrollees obtain less prenatal care, are less likely to quit smoking spontaneously, and gain less weight per week of gestation than first-trimester enrollees. In other words, there is no evidence from the analysis of maternal behaviors to support the protective effect of third-trimester WIC enrollment.

We also are surprised to find larger differences in spontaneous smoking quit rates by trimester of care when we limit the sample to only first births and women who initiate prenatal care in the first trimester (Table 8 versus Table 6). This stratification is aimed at reducing unobserved heterogeneity. The results for spontaneous quitting suggest that we may have worsened it, since there should be no association between the timing of WIC enrollment and spontaneous quitting. Indeed, the large differences in spontaneous quitting of smoking between prenatal and postpartum WIC enrollees raises questions as to usefulness of postpartum WIC enrollees as a comparison group for prenatal WIC enrollees. Women who initiate both prenatal care and WIC in the first trimester may be the most motivated of all enrollees. And yet, despite the greater tendency to quit smoking, first-trimester enrollees do not realize clinically meaningful gains in fetal growth, especially if we limit comparisons to prenatal WIC enrollees (Table 7). Put differently, if first-trimester enrollees are favorably selected on maternal behaviors, then the results for birth outcomes should be biased towards finding a protective effect of WIC.

CONCLUSIONS

The causes of preterm birth have baffled clinicians for several decades as few interventions have proven to be protective. Despite pessimism among clinicians, social scientists have claimed strong associations between participation in WIC and lower rates of preterm birth. A recent conjecture for the discrepancy between clinical and social research is that WIC represents a multifaceted approach to preterm birth that clinical trials neglect in their focus on a single factor.

This study uses data on the timing of WIC enrollment to correct limitations in previous observational studies. We are able to replicate the strong protective association between WIC participation and preterm birth frequently reported by social scientists. However, we conclude that the association is largely spurious, driven primarily by third-trimester enrollees with postpartum women as a comparison group. Indeed, the protective effect of WIC on preterm birth among third-trimester women is twice as strong as the effect for women who enroll in WIC in earlier trimesters of pregnancy. We could find no corroborating evidence to support a protective effect of WIC when we analyzed the impact of WIC participation on smoking, increased prenatal care, and maternal weight gain.

One limitation of our study is that it pertains to a single state. In future work we hope to add additional states and analyze additional outcomes related to prenatal and postpartum maternal behaviors. Based on this initial work, we would recommend that policymakers focus less on the association between WIC and birth outcomes, and instead structure incentives that help new and expectant mothers to constructively modify behaviors such as smoking, vitamin intake, breastfeeding, and timely immunizations.

Appendix
Description of the Smoking Variables

PREGRAVID SMOKING

Pregravid smoking status is based on three questions: (1) average number of cigarettes smoked per day three months before pregnancy; (2) a "change" variable indicating if the woman has decreased smoking from pre-pregnancy to pregnancy; and (3) a "change" variable, asked at the postpartum visit, indicating if the woman has decreased smoking from pre-pregnancy to postpartum. The first two questions are asked at the WIC prenatal interview, the third at the WIC postpartum visit. The two "change" variables are not dichotomous, but multiple-choice indicators that allow mothers to choose among responses such as "Smokes fewer cigarettes than before pregnancy," "Stopped smoking after becoming pregnant," or "Nonsmoker," among others. The exact questions are reproduced below. Buescher (1997) writes that inclusion of partially favorable answers increases smoking disclosure by pregnant women. In assigning smoking status, we therefore assume that there are no false positives—that is, we only need one affirmative response to classify a woman as a smoker, even if other variables show otherwise.

Postpartum registrants are only asked the postpartum "change" question noted above (Question 3 below). We use this variable to infer pregravid smoking by women who register for WIC only after giving birth.

PRENATAL SMOKING

We base smoking during pregnancy on: (1) current number of cigarettes smoked per day; (2) the "change" variable indicating if the woman decreased smoking from pre-pregnancy to pregnancy; and (3) responses to birth certificate questions on tobacco use during pregnancy. As with pregravid smoking, responses to the first two questions are not available for postpartum-only enrollees.

Women who were counted as pregravid nonsmokers but are smokers during pregnancy are reclassified as pregravid smokers. At the WIC prenatal interview, 230,649 responded that they did not smoke pre-pregnancy. At the same interview, 171 of these pregravid nonsmokers said that they started smoking after becoming pregnant. However, birth certificates belie this; they show that 8,487 of the pregravid nonsmokers smoked during pregnancy. Given these inconsistent responses and the unlikelihood of nonsmokers deciding to take up smoking during pregnancy, registrants who report not smoking pre-pregnancy but start during pregnancy are regrouped as pre-pregnancy smokers.

POSTPARTUM SMOKING

There is only one smoking question asked of WIC postpartum registrants: the “change” variable for smoking from pregravid to postpartum. We use this to classify women as postpartum smokers or nonsmokers. Prenatal registrants have more opportunities to disclose their smoking status compared with postpartum-only women. This may contribute to large differentials in pregravid and prenatal smoking rates between the two groups.

Variables for Generating Smoking Status

Timing of Smoking	Asked of Women Who Register for WIC Prenatally and Again Postpartum	Asked of Women Who Register for WCI Only Postpartum
Before Pregnancy	a. Cigarettes per day three months before pregnancy[a] b. Decrease in smoking from pre-pregnancy to pregnancy[a,b] c. Decrease in smoking from pre-pregnancy to postpartum[c,d]	a. Decrease in smoking from pre-pregnancy to postpartum[c,d]
During Pregnancy	a. Current number of cigarettes per day[a] b. Decrease in smoking from pre-pregnancy to pregnancy[a,b] c. Mother's tobacco use during pregnancy[e] d. Cigarettes per day during pregnancy[e]	a. Mother's tobacco use during pregnancy[e] b. Cigarettes per day during pregnancy[e]
Postpartum	a. Decrease in smoking from pre-pregnancy to postpartum[c,d]	a. Decrease in smoking from pre-pregnancy to postpartum[c,d]

[a]Asked at the WIC Prenatal interview
[b]Possible responses:
- (a) Smokes same number of cigarettes as before pregnancy
- (b) Smokes fewer cigarettes than before pregnancy
- (c) Stopped smoking after becoming pregnant
- (d) Tried to stop but is still smoking
- (e) Nonsmoker

[c]Asked at the WIC Postpartum interview. Not available for prenatal-only registrants.
[d]Possible responses:
- (a) Smokes same number of cigarettes as before postpartum visit
- (b) Smokes fewer cigarettes than before postpartum visit
- (c) Stopped smoking after becoming pregnant
- (d) Tried to stop but is still smoking
- (e) Nonsmoker

[e]From Vital Records

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