Matern Child Health J (2010) 14:318–331
DOI 10.1007/s10995-009-0452-7

Maternal Smoking and the Timing of WIC Enrollment

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Published online: 21 February 2009

Abstract *Objective*: To investigate the association between the timing of enrollment in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and smoking among prenatal WIC participants. *Methods*: We use WIC data from eight states participating in the Pregnancy Nutrition Surveillance System (PNSS). We adjust the association between the timing of WIC participation and smoking behavior with a rich set of maternal characteristics. *Results*: Women who enroll in WIC in the first trimester of pregnancy are 2.7% points more likely to be smoking at intake than women who enroll in the third trimester. Among participants who smoked before pregnancy and at prenatal WIC enrollment, those who enrolled in the first trimester are 4.5% points more likely to quit smoking 3 months before delivery and 3.4% points more likely to quit by postpartum registration, compared with women who do not enroll in WIC until the third trimester. However, among pregravid smokers who report quitting by the first prenatal WIC visit, first-trimester enrollment is associated with a 2% point increase in relapse by postpartum registration. These results differ by race/ethnicity; white women who enroll early are 3.6% points more likely to relapse, while black women are 2.5% points less likely to relapse. *Conclusions*: Early WIC enrollment is associated with higher quit rates, although changes are modest when compared to the results from smoking cessation interventions for pregnant women. Given the prevalence of prenatal smoking among WIC participants, efforts to intensify WIC's role in smoking cessation through more frequent, and more focused counseling should be encouraged.

Keywords WIC · Cigarette smoking · Birth outcomes

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Introduction

Tobacco exposure during pregnancy has been recognized as one of the leading preventable causes of adverse birth outcomes since the Surgeon General's report of 1964 called attention to the association between smoking during pregnancy and low birth weight. Subsequent reports expanded the list of adverse associations to include placental complications, fetal and perinatal mortality, SIDS, and other effects [1].

As public awareness of the dangers of tobacco has grown, the number of women who smoke during pregnancy has declined. In 2004, only 10.2% of women smoked during pregnancy, a 48% drop from 1989 [2]. While the decline is substantial, it conceals significant variations in smoking by race/ethnicity and socioeconomic status. For instance, 13.8% of white women smoked during pregnancy in 2004 compared with 8.4% of blacks and 2.6% of Hispanics. Differences by maternal education are also stark.

Twenty-four percent of high school dropouts (9–11 years of schooling) smoked during pregnancy, whereas women with 12, 13–15, and 16 or more years of schooling smoked at rates of 14.9, 8.4, and 1.5%, respectively [2]. Moreover, these figures underestimate the true prevalence of prenatal smoking [3]. The simple yes/no screen for prenatal smoking on birth certificates is less likely to elicit accurate responses than more detailed inquiries on frequency and timing, and all self-reports of maternal smoking, regardless of how specific the questions, are less sensitive than screens based on biological markers [4–6].

Estimates of the magnitude of the effect of prenatal tobacco exposure vary with the outcome examined, the study design, the population studied, and the period when the investigation was conducted. For example, case control studies using Washington State birth certificate data estimated that smokers during pregnancy have twice the risk of placenta praevia, a relationship confirmed in a cohort study from the Swedish Medical Birth Registry that examined records of 1.8 million deliveries in that country from 1973 to 1990 [7, 8]. An increase in the odds of premature rupture of membranes associated with smoking has been estimated between 1.6 and 2.1 [9, 10]. Most importantly, estimates of the average reduction in birth weight associated with smoking during pregnancy range on the order of 250 g, and these reductions are dose dependent [11]. Given the documented prevalence of prenatal smoking among poor women and the magnitude of its effects on birth outcomes, interventions that reduce maternal smoking have the potential to significantly improve birth outcomes among poor and near-poor women.

One of the largest federally sponsored programs that specifically targets this population of pregnant women is the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), which combines nutritional support with counseling and enhanced referral services to improve the health of pregnant women and their offspring. A crucial feature of WIC counseling is its emphasis on smoking prevention and cessation. In this study, we examine smoking among pregnant women who participate in WIC. We test whether greater exposure to WIC during pregnancy is associated with decreases in the prevalence of smoking, smoking cessation, and postpartum relapse. Data are from selected states that participate in the Pregnancy Nutrition Surveillance System (PNSS). The PNSS provides large samples of women with information on the exact date of enrollment in WIC along with screens for smoking before, during and after pregnancy.[1]

WIC participants are a particularly apt group on which to focus. First, over 40% of all births in the U.S. are to women on WIC, the vast majority of whom have incomes below 185% of the federal poverty level. Second, the prevalence of smoking is much greater among WIC participants than the national average. In 2006, 44.7% of white non-Hispanic women in the PNSS smoked 3 months prior to pregnancy, 27.3% reported smoking 3 months before delivery, and 35% smoked postpartum. Comparative figures for black non-Hispanic women pre-pregnancy, pre-delivery, and postpartum are 17.8, 9.3, and 17.3%, respectively.[2]

A third reason to focus on WIC and smoking is the growing debate on whether the reported association between WIC and improved birth outcomes is causal [12–17]. There is little evidence in the clinical literature to suggest that nutritional supplementation in a developed country like the US is protective against preterm birth and fetal growth retardation [18, 19]. Those who defend a causal association between WIC and improved birth outcomes argue that WIC provides more than nutritional support [14, 17]. Health education and timely referrals, they argue, may be the more effective aspects of the program. Counseling on the dangers of smoking is cited as important example. To date, however, little evidence has emerged that links prenatal participation in WIC with decreases in maternal smoking.

In this paper, we provide the first population-based assessment of the association between prenatal WIC participation and maternal smoking using information about smoking that is substantially more detailed than what has been available from previous studies of WIC [20–23]. We describe the prevalence of smoking among WIC recipients before, during and after pregnancy, and we create indicators of smoking cessation and relapse. Generating population-level estimates of the correlation between early exposure to WIC and smoking behavior during pregnancy and after delivery provides an important test of one important aspect of WIC's role in advancing maternal and infant health.

Background

Efficacy of Smoking Interventions

Public maternity health clinics, many of which offer on-site WIC programs, ought to be promising venues to encourage smoking cessation among poor women, yet projects described in the literature yield mixed results. In

[1] The Pregnancy Nutrition Surveillance System (PNSS) monitors the health and nutritional status of low-income pregnant women and infants in federally funded programs. The overwhelming majority of women in the PNSS are enrolled in WIC: http://www.cdc.gov/pednss.

[2] http://www.cdc.gov/pednss/pnss_tables/pdf/national_table11.pdf.

the 1986 Smoking Cessation in Pregnancy project, pregnant smokers on WIC and in public health clinics received short counseling sessions and self-help literature [24]. In the 8th month of pregnancy, the treated group had significantly higher self-reported quit rates compared with the control group (13 vs. 9.5%). However, "verified" quit rates, obtained by analyzing urine specimens for cotinine, were not significantly different (5.9 vs. 6.1%).

A randomized trial looked at the impact of including smoking cessation advice in prenatal care. Urine specimens were analyzed to verify quitting. There were no significant effects of counseling in preventing relapses during pregnancy or at the six-week postpartum follow-up [25]. Another trial randomly assigned pregnant women who had smoked earlier in pregnancy but had quit by the first prenatal visit to receive either usual physician advice or more structured advice along with individual relapse counseling [26]. Researchers found no difference either in relapse rates during pregnancy, or at 1 year postpartum. Other researchers reported higher verified quit rates for pregnant smokers receiving interventions, with one of two treatment groups having significantly higher quit rates than the control group (14 vs. 2%). [27].

A more recent program randomized six community health centers serving WIC participants to either special intervention or usual care [28]. Intervention clinics provided tailored cessation services and systematic follow-ups. The mean abstinence rate in intervention clinics (26%) significantly exceeded that in usual care clinics (12%). This effect was not sustained at 3- and 6-month postpartum follow-ups.

A summary of the literature on prenatal smoking interventions found that effective programs used "designated providers" who were enlisted specifically to provide anti-smoking advice [29]. The authors noted that "minimal contact programs that relied on existing staff" had inconsistent results. Successful programs provided plenty of reinforcement, including one-on-one contact, home visits, and printed materials. A more recent review reinforced these points: a brief cessation session of as little at 5–15 min when delivered by a trained provider can achieve significant increases in prenatal smoking cessation when compared to routine advice on the dangers of smoking [30].

It is unclear, however, whether WIC, as currently structured, can deliver even the brief but focused services that effective intervention programs entail. A 2001 GAO report to Congress, while not specifically focused on smoking cessation, found that among six WIC agencies studied, individual counseling averaged 4–17 min [31]. Agencies are mandated to offer only two sessions every 6 months. However, recipients are not required to attend any sessions, whether they are nutrition- or smoking-oriented [12, 32].

Methods

Data are from the Pregnancy Nutrition Surveillance System (PNSS), a public health monitoring system overseen by the Centers for Disease Control and Prevention (CDC). State participation in the PNSS is voluntary; currently, only 22 states and three tribal governments submit records to the CDC. The PNSS was created to assess maternal nutrition needs and the prevalence of adverse birth outcomes among low-income women. Ninety-nine percent of the PNSS records are sourced from prenatal and postpartum WIC interviews of participating states, with the remainder coming from other public health programs. Clinics collect the data, which are then aggregated at the state level before being submitted to the CDC on a quarterly basis.[3] PNSS combines the advantage of administrative data and its detailed information on the timing of WIC enrollment with that of survey data and its information on health outcomes and behaviors. PNSS data on maternal health and behaviors are richer than those available from birth certificates, which have been the primary source of outcomes in previous prenatal WIC evaluations using secondary data [20–23, 33–36].

Access to PNSS records was granted on a state-by-state basis. We requested data from 10 states with the largest caseloads: Florida, Georgia, Illinois, Indiana, Michigan, Missouri, North Carolina, New Jersey, Ohio, and Virginia. The North Carolina Division of Public Health granted access to NC data, while the CDC provided records for the nine other states.

We eventually dropped Georgia due to missing pregravid smoking records, and Illinois due to incomplete information on the timing of WIC enrollment. Information on late-pregnancy and/or postpartum smoking is missing for Florida, Indiana, and New Jersey. Our results therefore include estimates with and without these three states, depending on the smoking outcome.

We limit the sample to singleton-birth women who enrolled in prenatal WIC, excluding those who do not sign up until the postpartum period, as these women would have no information on pregravid smoking. This sample of 1,925,387 women is further restricted to those who have a complete set of indicators on smoking before pregnancy and smoking at WIC registration. We also drop women who enroll in WIC less than 5 weeks into their pregnancies. In doing so, we assume that there may be measurement error; because the first missed period is typically not detected until 4 weeks after the last one, it seems implausible for a woman to be able to detect pregnancy as well as seek prenatal care and WIC appointments within 5 weeks of conception. These exclusions, along with an additional 60 women dropped due to missing ages, result in another 156,417

[3] http://www.cdc.gov/pednss/what_is/pnss/index.htm.

Table 1 Distribution of prenatal WIC participants with complete records, by states and timing of WIC enrollment: singleton births

	First trimester	Second trimester	Third trimester	Total
FL (2000–2004)	69,062	110,537	61,878	241,477
IN (1995–2004)	88,939	89,320	48,108	226,367
MI (1996–2004)	103,474	120,918	68,821	293,213
MO (1995–2004)	140,589	101,944	51,409	293,942
NC (1996–2003)	115,757	120,140	62,392	298,289
NJ (2000–2004)	23,235	44,831	23,525	91,591
OH (1999–2004)	104,745	116,700	74,974	296,419
VA (2004)	9,276	12,208	6,188	27,672
Total	655,077	716,598	397,295	1,768,970

(8.8% of the final count) women removed from the regression samples. Table 1 shows the set of states and years used in our various analyses and the number of WIC participants by trimester of WIC enrollment. In the full sample (including FL, IN, and NJ), we have almost 1.8 million observations.

Smoking Outcomes

WIC participants are asked about smoking at various points when they register during pregnancy and at their postpartum visit. At prenatal enrollment, women are asked about: (1) smoking and number of cigarettes smoked per day 3 months before pregnancy; (2) current smoking and number of cigarettes per day; (3) a multiple-choice question about the change in smoking from the point just prior to pregnancy. The latter question allows the women to choose among responses such as “I quit as soon as I was pregnant”, “I reduced/increased my smoking” or “I tried to quit but failed”. Buescher (1997) writes that inclusion of partially favorable answers increases smoking disclosure by pregnant women [3]. In assigning smoking status at any point, 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. Over 16,000 women (less than 1% of the regression sample or 1.5% of the final tally of pregravid smokers) who were initially counted as pregravid nonsmokers but were smokers during pregnancy are also reclassified as pregravid smokers. (Not reclassifying does not significantly change results.) At postpartum enrollment, women are asked about: (1) smoking during the last 3 months of pregnancy and (2) smoking as of the postpartum period. In North Carolina, there is no explicit question about smoking during the last 3 months of pregnancy. PNSS files in North Carolina are linked to birth certificates, however; we use the smoking indicator on birth certificates as a proxy for late-pregnancy smoking. (Regressions using this indicator do not significantly differ when North Carolina is excluded from the sample.)

The screen for smoking is substantially more detailed than what has been available from linkages of administrative data and birth certificates.[4] We describe not only the prevalence of smoking among WIC recipients before, during and after pregnancy, but also create indicators of smoking cessation and relapse. The prevalence of smoking is simply the proportion of all women who report smoking at a specific point around pregnancy. To measure quitting, we analyze the subset of women who report smoking both 3 months before pregnancy and at the interview for prenatal WIC enrollment. These same women are asked at the postpartum interview whether they currently smoke and whether they smoked 3 months before delivery. Thus, a woman is characterized as having quit if she smokes at the prenatal interview, but reports not smoking 3 months before delivery. We create a second indicator of quitting if she smokes at the prenatal interview, but not at postpartum. We then associate quitting to the timing of WIC enrollment.

Participation in WIC may also prevent relapse. Our indicator of relapse is derived from the subset of women who smoked 3 months before pregnancy but who report not smoking at the prenatal interview. A woman is characterized as having relapsed if she reports smoking at the postpartum interview.[5] If WIC facilitates quitting and

[4] Arguably the most influential study of WIC based on linkages between birth certificates and administrative data is the 1992 article by Devaney, Bilheimer, and Schore [21]. Remarkably, there was no indicator for smoking. More recent linkages have relied on the dichotomous question, “Did you smoke during pregnancy?” which is available on birth certificates. There is no indication on the timing of smoking or whether the woman has changed the amount she smokes. Thus, a woman who smoked in the first trimester but then quit should technically answer yes but it is unclear how many do [20, 22, 23].

[5] There is more than one possible category of relapsers. One consists of smokers who quit by prenatal WIC enrollment and are marked as having resumed by postpartum registration. Another is the group of women who were still smoking at prenatal WIC, reported quitting sometime within the last 3 months of pregnancy, and resumed postpartum. We chose the first category because of the clearer sequence between exposure to WIC and changing the smoking decision. That is, a woman quits before prenatal WIC, has a chance to hear reinforcing antismoking advice by enrollment, then has the

protects against relapse, then we would expect that women who enroll early in pregnancy will be more likely to quit or not relapse than women who enroll later and who have less exposure to the nutritional and health education messages provided by WIC.

Quality of the Smoking Measures

In the absence of biological markers, we have sought to validate the smoking prevalence data obtained in the PNSS sample through comparisons to previously published data from other sources and through associations with observable biological consequences of tobacco exposure among PNSS newborns.

Comparisons with BRFSS and Birth Certificates

Research suggests that the accuracy of smoking classification can be improved by inquiring about pre-pregnancy smoking, which women are more likely to report, as well as letting smokers convey behavioral changes, such as quitting during pregnancy or decreasing the amount smoked, via multiple-choice questions [5]. Results from a randomized trial show that such questions significantly improve disclosure rates compared with a dichotomous (yes/no) format, such as those found on birth certificates [6]. The PNSS not only incorporates multiple-choice questions, but also elicits information on quantity smoked before and during pregnancy. Further, women who return to enroll postpartum are again asked about late-pregnancy and current smoking, potentially enhancing disclosure among women who relapse after prenatal WIC registration. Comparisons of the smoking prevalence among our PNSS population with those from other sources such as the Behavioral Risk Factor Surveillance System[6] indicate that for women of comparable socio-economic status, our measures are very similar to those reported elsewhere (data available upon request).

Smoking and Birth Weight

An indirect way to assess the quality of the smoking measure in the PNSS is to estimate its association with birth weight and other birth outcomes. The impact of prenatal smoking on birth weight is one the most consistent and widely accepted epidemiological findings in the literature [1]. We should find, therefore, that the adjusted mean differences in birth weight among women who report no smoking should exceed those of women who smoked 3 months before pregnancy since not all pregravid smokers quit. Similarly, women who report smoking before but not during pregnancy should have higher mean birth weights than those who continue smoking during pregnancy. Similar patterns should hold when we stratify by the intensity of smoking. The presentation of this evidence begins with Fig. 1, which shows the unadjusted mean birth weight by four levels of smoking: (1) non-smokers; (2) women who smoked only before pregnancy; (3) women who smoked before pregnancy and at WIC enrollment but who reported not smoking in the last 3 months before delivery; and (4) women who smoked before pregnancy, at WIC enrollment and in the last 3 months of pregnancy. There is essentially no difference in mean birth weight between non-smokers and those who smoked 3 months before pregnancy but who reported not smoking thereafter. This provides some confidence for the accuracy for our smoking screen since we would expect no difference in birth weight between non-smokers and pregravid smokers, if the latter truly stopped when pregnant. By contrast, the difference in mean birth weight between non-smokers and women who smoked 3 months before delivery is substantial, about 200 g, which accords well with the epidemiological literature. Women who report smoking at the WIC enrollment but who claim to have stopped by the third trimester show a deficit in birth weight that is approximately one-third as large as that among women who reported smoking in the 3 months before delivery. This difference also accords with the epidemiological literature. In a study that used a randomized design with a biological marker to screen for smoking, women who stopped before the 8th month of pregnancy had infants whose birth weights were less but did not differ significantly from those who quit smoking before randomization [37]. This relationship between smoking and birth weight persists across race and ethnicity.

In Fig. 2, we repeat these comparisons for the incidence of low birth weight (<2500 g), preterm birth (<37 weeks gestation) and small for gestational age (SGA).[7] The pattern observed for mean birth weight is evident for low birth weight and SGA but not preterm birth, which again largely conforms to the literature. The association between prenatal smoking and preterm birth is much less pronounced than its association with fetal growth retardation [18].

As a further indication that our smoking screen has credible accuracy, we show the adjusted mean differences in birth weight, birth weight controlling for gestation, and SGA by the timing of smoking and smoking intensity

Footnote 5 continued
period until the postpartum interview to stay quit or relapse. For the second category, capturing smokers who quit during WIC exposure is more difficult as these women may have very little time to quit between enrollment and the last 3 months of pregnancy. This would be particularly problematic for 3rd-trimester participants, e.g., those enrolling in the 8th month of pregnancy who only had until month 9 to quit.

[6] http://www.cdc.gov/brfss/.

[7] We used the cutoffs as reported by Alexander, et al. (1998) [38].

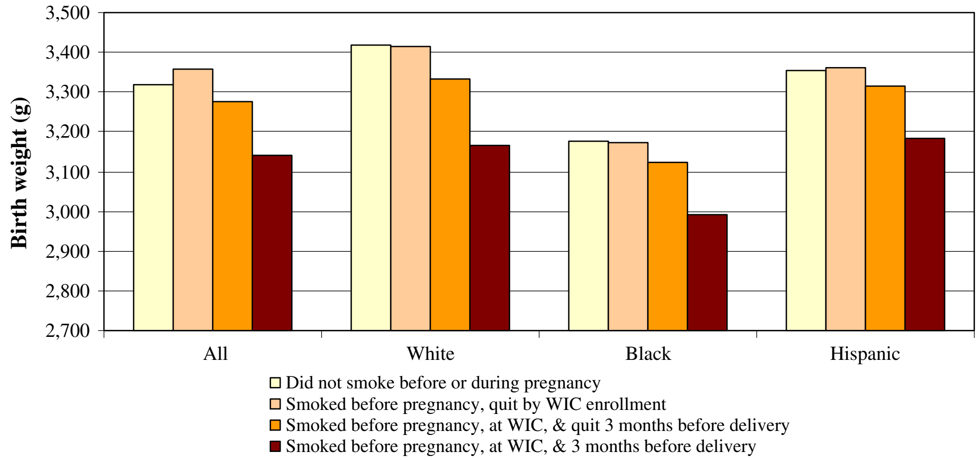

Fig. 1 Mean birth weight, by smoking status before and during pregnancy

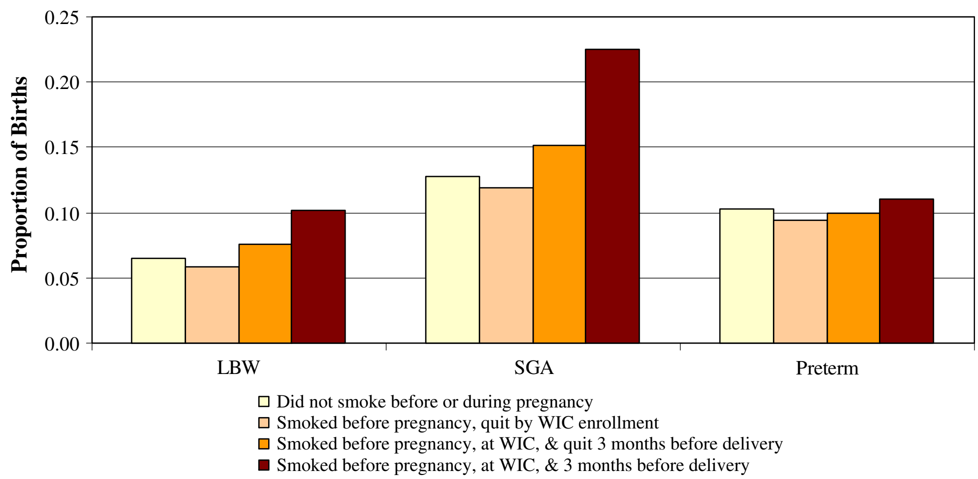

Fig. 2 Mean LBW, SGA, and preterm, by smoking status before and during pregnancy

(Table 2). There is impressive consistency along several dimensions: (1) women who report smoking 10 or fewer cigarettes per day experience the smallest birth weight deficits; (2) this dose-response holds regardless of whether smoking is ascertained before, during or after pregnancy; and (3) the pattern persists in the full sample of states and when we limit the sample to Missouri, North Carolina and Ohio (columns 2–4).[8]

In sum, biologically verified screens for smoking based are indisputably the preferred standard. Nevertheless, detailed questions at various points around pregnancy are more practical for large populations and administrative data bases. The smoking screen in the PNSS appears superior to birth certificates and provide associations with birth outcomes that are consistent with more refined screens.

Empirical Model

We are interested in the association between exposure to WIC and smoking. If WIC's nutritional and health education messages are effective, then the longer a women is enrolled in WIC during pregnancy, the less likely she should smoke, the more likely she should quit, or the less likely she should relapse if she had quit before enrolling in WIC. A linear version of our empirical model is as follows (we have suppressed subscripts for simplicity):

$$S = \alpha_0 + \alpha_1 \mathrm{WIC}_1 + \alpha_2 \mathrm{WIC}_2 + \mathbf{X}\beta + \mathrm{e}. \quad (1)$$

Let S be an indicator of smoking; let the WIC_k variables indicate the trimester of pregnancy a woman enrolled in the program. We expect $\alpha_1 < \alpha_2 < 0$ for smoking participation and relapse and the reverse for desirable outcomes such as quitting. The omitted group consists of women who do not sign up for WIC until their third trimester. We also adjust for characteristics of the mother such as race/ethnicity, age, marital status, pre-pregnancy BMI, parity, poverty level, participation in Medicaid/TANF/Food Stamps, household size, and include state and year fixed effects (**X**). Finally, let e be the error term.[9]

[8] These states have data for both gestation and smoking outcomes.

[9] Because there has been little change in smoking in the states and years of our sample, we do not include cigarette prices in this model. Following Levy and Meara (2006), we tested changes in smoking around the time of the 1998 Master Settlement Agreement [39].

Table 2 Adjusted differences in birth weight and fetal growth among prenatal WIC enrollees with complete records, by smoking status

	Birth weight: All States (1)	Birth weight: MO, NC, OH (2)	Birth weight | gestation: MO, NC, OH (3)	Small for gestational age: MO, NC, OH (4)
Smoked before pregnancy	−113.6**	−112.9**	−112.7**	0.059**
Cigarettes/day before pregnancy (ref: no cigarettes/day)				
1–10	−83.5**	−89.1**	−91.0**	0.051**
11–20	−141.7**	−144.7**	−144.4**	0.083**
21+	−201.6**	−201.6**	−191.9**	0.114**
Smoked as of prenatal WIC	−150.5**	−135.2**	−132.1**	0.069**
Cigarettes/day at prenatal WIC (ref: no cigarettes/day)				
1−10	−164.6**	−164.4**	−159.3**	0.087**
11−20	−233.8**	−231.2**	−219.0**	0.130**
21+	−237.7**	−215.1**	−209.7**	0.131**
Mean dep var	3,281.8	3,266.6	3,266.6	0.153
N	1,670,877	849,565	849,565	849,565
Smoked last 3 months of pregnancy[a]	−194.0**	−196.5**	−187.7**	0.099**
Mean dep var	3,278.9	3,266.6	3,266.6	0.153
N	1,123,915	849,565	849,565	849,565
Cigarettes/day last 3 months of pregnancy (ref: no cigarettes/day)[b]				
1–10	−178.2**	−180.6**	−177.3**	0.096**
1–20	−224.5**	−226.8**	−223.1**	0.135**
21+	−255.9**	−256.1**	−248.2**	0.160**
Mean dep var	3,286.4	3,269.3	3,269.3	0.2
N	852,236	554,515	554,515	554,515
Smoked at postpartum WIC[c]	−158.8**	−152.2**	−144.6**	0.076**
Mean dep var	3,281.5	3,266.6	3,266.6	3,266.6
N	1,220,838	849,565	849,565	849,565
Cigarettes/day at postpartum WIC (ref: no cigarettes/day)[d]				
1–10	−167.1**	−168.2**	−164.8**	0.091**
1–20	−227.8**	−228.5**	−219.6**	0.131**
21+	−259.7**	−259.9**	−245.5**	0.148**
Mean dep var	3,287.9	3,269.3	3,269.3	0.165
N	927,815	554,515	554,515	554,515

[a] Data missing for FL, IN, NJ

[b] Missing for FL, IN, NC, NJ

[c] Missing for FL

[d] Missing for FL, IN, NC

[+] $P < 0.10$, * $P < 0.05$, ** $P < .01$

Although the statistical estimation of Eq. (1) is straightforward, obtaining unbiased estimates of treatment effects associated with WIC is quite challenging. In econometric terms, the coefficients on WIC, α_1 and α_2, estimate the average effect of treatment on the treated under two assumptions: first, that the decision to participate in WIC, conditional on **X,** is uncorrelated with smoking or the change in smoking prior to pregnancy; and second, that the expected gains to participation in WIC are constant across individuals or if they are not, then women have no way of anticipating the gains [40, 41]. These are strong assumptions and would be violated if, for example, women who enroll early in WIC are more health-conscious and more likely to quit than women who enroll later. Alternatively, women with more serious smoking problems may seek out WIC earlier in an effort to obtain help with their addiction. Ideally, we would like to use instrumental variables to purge these forms of selection bias, but we lack a credible instrument. Indeed, we know of no study that has been able to instrument convincingly for WIC participation.

Footnote 9 continued
Consistent with the authors' findings, we did not find any significant difference in smoking after the settlement.

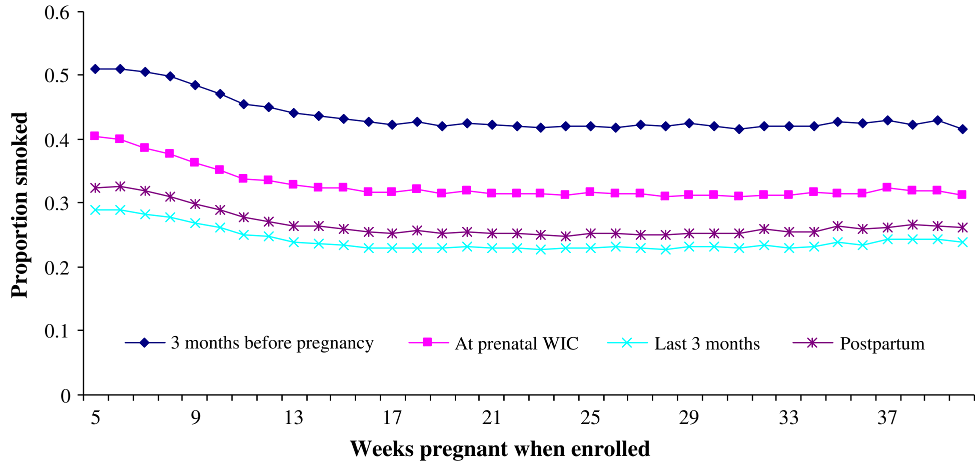

Fig. 3 Smoking among prenatal WIC enrollees, by weeks pregnant when enrolled in WIC: MI, MO, NC, OH, VA

Our identification strategy, therefore, takes several practical approaches. First, we are limited to only women on WIC, and thus, we compare the effect of early as opposed to late exposure to WIC on maternal smoking. One advantage of this comparison is that everyone is eligible for WIC and everyone participates. Stigma or other barriers to participation in publicly funded nutrition programs are thus unlikely to be factors in our analysis. Second, we have very large samples that enable us to analyze smoking separately for non-Hispanic whites, non-Hispanic blacks, and Hispanics.[10] Third, we use falsification checks as a means of flagging potential contamination from omitted variable bias. The clinical literature indicates that most pregnant smokers quit when they realize that they are pregnant; these women are often referred to as "spontaneous quitters" [25, 42–44]. Spontaneous quitting should be unrelated to the timing of WIC enrollment. Any association between early WIC enrollment and spontaneous quitting is likely due to selection bias, since quitting precedes enrollment. We have two indicators of spontaneous quitting. This first is a dichotomous indicator that is one if the woman smoked 3 months before pregnancy but reports not smoking at time of WIC enrollment. One limitation of this indicator is that we do not know when the woman quit. Thus, we also use a second indicator. At WIC enrollment, women are asked if they smoke, and if so, whether they have reduced their smoking or quit altogether. One of the possible responses is, "Stopped smoking before my first prenatal care visit."[11] We use this second indicator as a measure of spontaneous quitting and associate it with timing of WIC enrollment.

[10] 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 potentially important because smoking varies dramatically by race and ethnicity.

[11] For most women, registration for prenatal care precedes enrollment in WIC.

Results

The four smoking series in Fig. 3 show the prevalence of smoking at different points around pregnancy by week of enrollment in WIC. Consider women who enroll in WIC in the 13th week of pregnancy. Approximately 45 percent smoke 3 months before pregnancy; 35% continue to smoke when questioned at prenatal enrollment into WIC; approximately 26% report smoking 3 months prior to delivery and 28% smoke at the postpartum interview. Much of the data in Fig. 3 previews the results. First, the prevalence of smoking at any point is always greater among women who enroll in WIC in the first trimester but differences with respect to timing of WIC enrollment remain relatively flat thereafter. Second, the difference in the prevalence of smoking between the different series at each week of enrollment reflects quitting. Again consider women who enrolled in WIC in the 13th week of pregnancy. The difference in smoking from the period 3 months before pregnancy to the point of WIC enrollment implies a quit rate of about 22% [(45–35)/45], which most likely represents spontaneous quitting. By contrast, the difference in smoking between those who smoke at enrollment and those who smoked 3 months before delivery is a margin over which WIC may be effective at promoting cessation. If WIC effectiveness on quitting is dose-dependent, however, we might expect the two series to converge as women enrolled in WIC later in pregnancy. In other words, if greater exposure to WIC's nutritional and health-educational messages is more effective than less exposure, then the percentage point decline in smoking, the vertical distance between the two series, should be greater the earlier a woman enrolls in WIC. In fact, we observe about an 8–9% point difference between the prevalence of smoking at WIC enrollment and the prevalence 3 months before delivery. The difference appears unchanged throughout pregnancy, which suggests that WIC has little dose-dependent impact on quitting, but we cannot discount

Table 3 Adjusted differences in the prevalence of smoking among prenatal WIC enrollees, by trimester of enrollment

	All	White	Black	Hispanic
Trimester of WIC enrollment	Smoked 3 months before pregnancy			
First	0.027**	0.018**	0.039**	0.017**
Second	−0.002+	−0.006**	0.006**	−0.001
Third	–	–	–	–
Mean dep var	0.394	0.545	0.245	0.102
N	1,768,970	997,099	481,598	241,243
Trimester of WIC enrollment	Smoked at WIC prenatal			
First	0.023**	0.027**	0.019**	0.007**
Second	0.002*	0.003+	0.003+	0.000
Third	–	–	–	–
Mean dep var	0.289	0.410	0.168	0.060
N	1,768,970	997,099	481,598	241,243
Trimester of WIC Enrollment	Smoked Last 3 Months of Pregnancy[a]			
First	0.000	−0.001	0.002	0.004*
Second	−0.011**	−0.012**	−0.006**	−0.002+
Third	–	–	–	–
Mean dep var	0.250	0.337	0.125	0.044
N	1,146,832	703,624	322,595	88,658
Trimester of WIC Enrollment:	Smoked Postpartum[a]			
First	0.005**	0.002	0.010**	0.005+
Second	−0.008**	−0.010**	−0.003*	−0.004*
Third	–	–	–	–
Mean dep var	0.302	0.399	0.167	0.079
N	1,146,832	703,624	322,595	88,658

Note: Enrollees with complete records and singleton births

+ $P < 0.10$, *$P < 0.05$, **$P < .01$

[a] FL, IN, NJ excluded due to missing data

Coefficients represent the change in the probability of the outcome, holding other covariates constant at their mean values. See footnote 10 in the text

the possibility that the program may exert a one-time threshold effect at the time of enrollment. The important caveat is that these differences are unadjusted for maternal characteristics. We turn next, therefore, to the multivariate analyses.

In Table 3 we show adjusted differences in the prevalence of smoking before, during and after pregnancy (α_1 and α_2 from Eq. 1). Estimates are obtained by probit regressions.[12] Based on the estimates in the first two panels, women who enroll in WIC in the first trimester are 2.7 percentage points more likely to be smoking before pregnancy and 2.3% points more likely to smoke at WIC enrollment than women who enroll in WIC in the third trimester. This represents about a 10% difference based on the mean prevalence of smoking at each point in time and suggests that early enrollees in WIC may be adversely selected with respect to smoking. In the bottom two panels, we display the adjusted prevalence of smoking 3 months before delivery and postpartum. Here we find no meaningful differences by the timing of WIC enrollment. The lack of a difference implies that women who enroll early in WIC are more likely to quit. In the next set of results we test this directly.

In Table 4 we focus on quitting and relapse. Quitting is based on the sub-sample of women who report smoking at prenatal WIC enrollment. Thirty-four percent of these women report quitting between prenatal enrollment and 3 months before delivery, and 23.3% report quitting between prenatal enrollment and the postpartum interview. The results in the top two panels indicate that the probability of quitting before delivery is 4.5% points greater among first trimester enrollees and 3.2% points greater among second trimester enrollees relative to women who

[12] We use the routine in Stata 9.2 to obtain marginal effects. In the case of dichotomous indicators such as the trimester of WIC enrollment, the routine reports the difference in the probability of the outcome with the indicator on and then off holding constant the other covariates at their mean values.

Table 4 Adjusted differences in smoking cessation and relapse among prenatal WIC enrollees by trimester of enrollment

	All	White	Black	Hispanic
Trimester of WIC	Smoked at WIC enrollment: Quit 3 months before delivery			
First	0.045**	0.045**	0.048**	−0.005
Second	0.032**	0.030**	0.041**	0.004
Third	–	–	–	–
Mean dep var	0.344	0.299	0.501	0.672
N	386,323	305,428	64,918	9,572
Trimester of WIC	Smoked at WIC enrollment: Quit postpartum			
First	0.034**	0.034**	0.031**	−0.010
Second	0.023**	0.022**	0.029**	−0.010
Third	–	–	–	–
Mean dep var	0.233	0.193	0.369	0.494
N	386,323	305,428	64,918	9,572
Trimester of WIC	Relapse: Quit before enrollment, smoked postpartum[a]			
First	0.020**	0.036**	−0.025**	−0.038
Second	0.000	0.006	−0.018*	−0.035+
Third	–	–	–	–
Mean dep var	0.308	0.301	0.33	0.323
N	123,941	88,063	27,968	5,071

Note: Enrollees with complete records and singleton births

+ $P < 0.10$, * $P < 0.05$, ** $P < .01$

[a] FL, IN, NJ excluded due to missing data

Coefficients represent the change in the probability of the outcome, holding other covariates constant at their mean values. See footnote 10 in the text

enroll in the last trimester. Overall, early enrollment in WIC is associated with a quit rate that is approximately 14% greater than late enrollees (0.045/0.344). The results for postpartum quitting are similar. The behavior of whites and blacks appear the same, but we find no association with the timing of WIC enrollment and quitting among Hispanics.

The bottom panel in Table 4 examines relapse. The sample includes women who report smoking 3 months before pregnancy, but who report not smoking at the prenatal interview. A woman in this sub-sample has relapsed if she reports smoking at the postpartum interview. Consider the results for all women. The mean relapse rate is approximately 31%. However, contrary to expectations, we find that first-trimester enrollment in WIC is associated with a 2% point increase in relapse. Moreover, there are important racial differences. White women who enroll in WIC in the first trimester are 3.6% points more likely to relapse whereas black women are 2.5% points less likely to relapse. Although the results for relapse appear inconsistent with those for quitting, they are not directly comparable since they are based on two different samples of pregravid smokers. The quitting sample includes all pregravid smokers who smoke at prenatal WIC enrollment whereas the relapse sample is all pregravid smokers who report not smoking at enrollment. However, if one of WIC's objectives is to promote maternal health among participants, then relapsing appears to offset some of the gains from quitting.

Lastly, we examine quitting by the intensity of pregravid smoking (Table 6). Most research indicates that light smokers (1–10 cigarettes per day) are more likely to quit during pregnancy than heavier smokers. The mean level of quitting in our sample of WIC enrollees is consistent with that finding. The pre-delivery quit rate among light smokers is 43.1% compared with 23.1% for women who smoke more than half a pack (11–20 cigarettes) and 15.3% among women who smoke more than a pack per day (21+). However, within each level of smoking, those who enroll in WIC in the first or second trimester are more likely to quit than those who enroll in the third trimester. The same pattern obtains for postpartum quitting (Table 5, middle panel). Turning to the results for relapse, we find that lightest smokers are less likely to relapse than the heaviest smokers (22.1 vs. 31.6%). Unexpectedly, early enrollment in WIC is associated with greater relapse. For instance, consider women who smoke up to a pack a day (11–20 cigarettes). Those who enroll in WIC early are 6.0% points more likely to relapse than those who enroll in the third trimester.

Table 5 Adjusted differences in smoking cessation and relapse by pre- pregnancy smoking levels and trimester of WIC enrollment

Cigarettes/day	1–10	1–20	21+
Trimester of WIC enrollment	Quit 3 months before delivery		
First	0.048**	0.052**	0.055**
Second	0.035**	0.033**	0.036**
Third	–	–	–
Mean dep var	0.431	0.231	0.153
N	140,155	160,390	54,266
Trimester of WIC enrollment	Quit postpartum		
First	0.041**	0.033**	0.032**
Second	0.028**	0.021**	0.021**
Third	–	–	–
Mean dep var	0.259	0.153	0.139
N	140,155	160,390	54,266
Trimester of WIC enrollment	Relapse postpartum		
First	0.018**	0.060**	0.079**
Second	−0.003	0.022*	0.013
Third	–	–	–
Mean dep var	0.221	0.298	0.316
N	64,384	29,049	4,337

Note: Pregravid smokers only: MI, MO, NC, OH, VA. Enrollees with complete records and singleton births. Quitting is based on the sub-sample of women who report smoking at enrollment. Relapse is derived from the subsample of pregravid smokers who report NOT smoking at prenatal enrollment

$^{+}$ $P < 0.10$, * $P < 0.05$, ** $P < .01$

Coefficients represent the change in the probability of the outcome, holding other covariates constant at their mean values. See footnote 10 in the text

Table 6 Falsification tests: Adjusted differences in quitting prior to WIC enrollment

	All	White	Black	Hispanic
Trimester of WIC	Quit by prenatal WIC enrollment			
First	−0.017**	−0.024**	0.019**	0.004
Second	−0.008**	−0.012**	0.006	0.005
Third	–	–	–	–
Mean dep var	0.243	0.224	0.301	0.347
N	510,264	393,491	92,886	14,649
Trimester of WIC	Quit Before First Prenatal Care Visit[a]			
First	0.000	−0.006	0.033**	0.033*
Second	0.001	0.000	0.008^{+}	0.025^{+}
Third	–	–	–	–
Mean dep var	0.326	0.332	0.306	0.312
N	458,012	360,972	77,059	12,114

Note: Pregravid smokers only: MI, MO, NC, OH, VA. Enrollees with complete records and singleton births. A woman is classified as a quitter if she reports not smoking at WIC enrollment or reports having quit before her first prenatal care visit

$^{+}$ $P < 0.10$, * $P < 0.05$, ** $P < .01$

[a] VA excluded due to missing data

Coefficients represent the change in the probability of the outcome, holding other covariates constant at their mean values. See footnote 10 in the text

A major concern with any evaluation of WIC based on observational data is selection bias. As noted above, we lack quasi-experimental variation in the assignment of WIC enrollment with which to identify treatment effects. Instead, we use falsification tests as way of uncovering possible biases. The outcome in each panel of Table 6 is whether a pregravid smoker quit before enrolling in WIC. Evidence of no bias would be a lack of an association between pre-WIC quitting and the trimester of WIC enrollment. The results are mixed. In the top panel of Table 6 we show that that whites are less likely to quit if they enroll early in WIC, but we find no evidence of an association in the lower panel in which women are asked if they quit by their first prenatal care visit. For blacks we find evidence of an association suggestive of positive selection bias. Black women who enroll in WIC early are more likely to report having quit prior to enrollment. The magnitude of the association is relatively large when compared to the coefficients on quitting among black women in Table 4. Thus, a substantial portion of the association between early enrollment in WIC and a greater likelihood of quitting (and a smaller likelihood of relapse) among black women is likely to have occurred without participation in WIC.

Discussion

We have shown in a broad population-based sample of women enrolled in the WIC program that smoking prevalence declines throughout the course of pregnancy while women are enrolled in the program. Among women in MI, MO, NC, OH, and VA, the five states with complete smoking records, the adjusted quit rate is 34.4%. Some of these women resume smoking after delivery so that in the postpartum period 30.2% reported smoking.

Although these WIC-associated declines in smoking prevalence appear significant, they are subject to important qualifications. First, and most importantly, most of the smoking cessation during pregnancy in this sample occurs, as has been reported in other data, at the time the women realize they are pregnant before they have enrolled in the WIC program. The pregravid smoking rate among women within the five states with complete smoking records was 44.5%. By prenatal WIC enrollment, prevalence was at 33.7%, a decline of 10.8% points. Three months before delivery, 25% of pregnant women smoked, so that during the period of actual participation in the WIC program, there was a decline of 8.7% points in smoking prevalence.

Second, we have no non-WIC women in our sample whose smoking behavior we can directly compare to the WIC participants. To understand how much of the smoking cessation dynamics in our sample are potentially attributable to WIC participation, we must compare our findings with what is known about changes in smoking behavior in general among pregnant women. Reviewing national data from the 1985 National Health Interview Survey, Fingerhut, et al. (1990) found that smoking prevalence before pregnancy was 52.5% among white unmarried women, a figure nearly identical to the 54.5% among white women in our sample [45]. In the Fingerhut study, 39.6% of these women quit smoking during pregnancy, 27% early in pregnancy. In our sample among white women, smoking prevalence declined from 54.5 to 41% by the time of WIC enrollment, a decrease of 25%. Although we do not know what percent of women in Fingerhut's sample participated in the WIC program, the similarity of the changes in smoking prevalence between Fingerhut's unselected data and our own suggest that women's decisions to alter their smoking behavior may have little to do with WIC participation.

Despite these reservations, our data do lend credence to the belief that WIC participation has some influence on smoking behavior. Exploiting the timing of WIC enrollment, we were able to demonstrate that first trimester enrollment in WIC is associated with rates of smoking cessation that are 14% higher (4.5% points on a mean quit rate of 34.4%; see Table 3) than late WIC enrollment. When we restrict our sample to women who enroll early in prenatal care we find identical results. This suggests that these incremental quit rates represent true WIC effects beyond what might be expected from prenatal care participation alone. However, the effect of such modest quit rates on birth weight is unlikely to be substantial. Assume a mean incidence of low birth weight of 10 percent and a population attributable risk for low birth weight associated with smoking of 0.20. Based on our estimates, early enrollment in WIC increases quit rates by 4.5% points. The expected declined in rate of low birth weight associated with early WIC and attributable to smoking cessation would be 0.27% point [0.20*10*(4.5/33.7)].

This evaluation is important for a number of reasons. First, the eight-state sample from which the data are derived represents one of the largest national population-based compendiums of WIC participants published to date. Moreover, the screen for smoking in these data is much more detailed than has been available from previous administrative databases. We also adjust our estimates with a relatively rich set of covariates, each of which is interacted with indicators of race and ethnicity in an effort to minimize selection bias inherent in observational design. In addition, we use falsification tests that suggest no major contamination from omitted variables among whites, but do point to positive selection among blacks. The strength of the data combined with the analytic approach leads us to conclude that these findings likely represent as accurate a picture of the effect of WIC participation on smoking cessation as is currently available from observational data.

The second important aspect of the current study involves its public policy implications. Smoking ranks as one of the most powerful risk factors for adverse birth outcomes that is preventable with changes in maternal behavior during pregnancy and the prevalence rate of tobacco use among women eligible for the WIC program is lamentably high, particularly among white women. While controversy has arisen regarding the potential for the nutritional supplementation provided by WIC vouchers to plausibly exert significant effects on birth outcomes, increasing the rate at which women quit smoking would have clear benefits for participants in this program. Our findings suggest earlier enrollment demonstrates a small but significant advantage with respect to smoking cessation compared to later enrollment. Nevertheless, the increased quit rates associated with early enrollment in WIC are unlikely to explain the 2–3% point declines in low birth weight attributed to WIC in recent observational studies [13, 14, 17, 46].

Compared with the impact of focused smoking cessation programs, the WIC effects on smoking cessation described in our study are small. In a summary of 16 trials, Melvin, et al. (2000) found that women who received low-intensity but focused advice to reduce prenatal smoking were 70% more likely to quit than women who received routine prenatal care [30]. In this study, we show that quit rates are approximately 14% greater among early compared to late WIC enrollees. Since many of the studies reviewed in Melvin's summary involve focused counseling across multiple visits, the more modest findings in our study raise the issue of how frequent and how targeted WIC smoking cessation counseling is in practice. From a policy standpoint this is important since it is questionable whether a differential of the magnitude we have characterized would be likely to have a significant impact on birth outcomes.

There are several limitations to this study that must be acknowledged. It is an observational study limited to a sample from eight states. The problem of unobservables, while mitigated by the analytic approach, cannot be eliminated completely. Without biological markers of tobacco exposure the issue of potential misclassification will be impossible to avoid. Heterogeneity in the content of WIC programs across states means that these findings are averages within which some variation in WIC effectiveness is to be expected. PNSS does not include information on the number of counseling sessions; the timing of WIC enrollment is therefore a proxy for the intensity of exposure, as early enrollees have at least the opportunity to receive more frequent interventions, compared with those who sign up closer to delivery. Finally, the absence of smoking information from before pregnancy on those women who enrolled in WIC after delivery denied us the opportunity to compare directly women enrolled in WIC during pregnancy with women enrolled in WIC postpartum.

Despite these caveats we believe that the available evidence from this large population-based sample of WIC women indicates that participation in WIC may have the potential to increase the rate at which women quit smoking while pregnant but that there appears to be ample room to improve WIC's performance in this regard. Heretofore, the nutritional subsidies of WIC have garnered much of the attention from researchers and policy makers alike. It may be that some of this attention should be redirected. Given the extent of prenatal tobacco exposure among this population and the potential benefits to the women and their babies, efforts to intensify WIC's role in smoking cessation through more intensive, more frequent and more focused counseling should be encouraged. Further, given that there is some evidence that properly equipped clinics can deliver effective interventions, the WIC program may consider providing systematic funding and training to prenatal care providers frequented by WIC participants. The as yet unrealized benefits of WIC as a vehicle to decrease smoking activity among pregnant women presents an important opportunity toward which the increased attention of the research and policy communities is warranted.

Acknowledgments The research was supported by a grant from the USDA Food and Nutrition Research Program to the National Bureau of Economic Research (# 59-5000-6-0102). We thank Karen Dalenius from the Centers for Disease Control and Prevention (CDC) for help with the PNSS file and special thanks to WIC Program administrators in various state offices. These include Najmul Chowdhury (North Carolina), Patrice Wolfla (Indiana), Nancy Hoffman (Missouri), Penny Roth (Illinois), and Lisa Armstrong (Virginia). We would also like to acknowledge input from John Karl Scholz at the University of Wisconsin, Elizabeth Frazao from the Economic Research Service and Jay Hirschman at the USDA Food and Nutrition Bureau. All opinions are those of the authors and do not represent those of the various state WIC programs, the CDC or the USDA.

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