ESSAYS IN THE EVALUATION OF WIC, THE SPECIAL SUPPLEMENTAL NUTRITION PROGRAM FOR WOMEN, INFANTS, AND CHILDREN

by

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Abstract

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Decades of research have resulted in near-unanimous praise for the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), most notably for its impact on birth outcomes. Clinical research reveals a disconnect between most WIC analyses and the consensus among health practitioners: effective interventions for preterm birth, itself an outcome of interest as well as a factor influencing birth weight, remain unknown.

Two papers comprise this dissertation. The first reexamines the relationship between WIC and birth outcomes using data from the Pregnancy Nutrition Surveillance System (PNSS). We show that the longer women delay participation, the lower the rates of low birth weight and preterm birth. The large adjusted differences in outcomes between prenatal WIC participants and those who do not enroll until postpartum are largely driven by late-term enrollees, women already having longer gestations for reasons unrelated to WIC. We also look at the association between WIC and fetal growth retardation, an outcome more plausibly affected by maternal nutrition, health referrals, and counseling, particularly anti-smoking advice. We find a positive impact of WIC on fetal growth, though program effects are much smaller than previously estimated and are

not consistently supported by corresponding changes in maternal behavior such as prenatal smoking and weight gain.

The second paper more closely examines the relationship between smoking and the timing of WIC participation. Overall, we find that, compared with third-trimester enrollees, first-trimester participants are more likely to report smoking pre-pregnancy and at WIC enrollment. We do not find a consistent impact on smoking at points WIC can influence: in the last three months of pregnancy or at postpartum. We do find that women who enroll in the first and second trimesters are more likely to smoke before pregnancy and as of WIC registration compared with third-trimester enrollees. The greater propensity of early enrollees to smoke points to an opportunity for the program to systematically influence significant numbers of smokers during the first part of their pregnancies.

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Chapter 1: Reassessing the Association Between WIC and Birth Outcomes

I. Introduction

Decades of research have resulted in near-unanimous praise for the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), most notably for its impact on birth outcomes. The General Accounting Office (1992) estimated a 3-to-1 benefit-cost ratio for the program. "WIC works," former Agriculture Secretary Dan Glickman said, "perhaps better than any other government program in existence."

The GAO assessment, like much of the WIC literature, was limited to the program's prenatal component, which serves just 11% of the WIC population. The GAO's conclusion that prenatal WIC cut down rates of low birth weight (LBW) by 25% and very low birth weight by 44% is typical, as is Bitler and Currie's (2005) more recent finding that WIC reduces preterm birth by 29%.

LBW is governed either by length of gestation, rate of fetal growth, or a combination of these factors (World Health Organization, 2004; Kramer, 1987). Clinical research reveals a disconnect between most WIC analyses and the consensus among health practitioners: effective interventions for preterm birth (<37 weeks gestation), itself an outcome of interest as well as a factor influencing birth weight, remain unknown (Institute of Medicine, 2007). Given this, associations between WIC and birth weight should be caveated, and correlations with preterm birth interpreted as spurious.

This paper reexamines the relationship between WIC and birth outcomes using rich data from the Pregnancy Nutrition Surveillance System (PNSS). The PNSS has exact dates of prenatal WIC enrollment, identifying when during pregnancy a woman enrolled in WIC. We show that the longer women delay participation, the lower the rates of low birth weight and preterm birth. The large adjusted differences in outcomes between prenatal WIC participants and those who do not enroll until postpartum are largely driven by late-term enrollees, women already having longer gestations for reasons unrelated to WIC.

We also look at the association between WIC and IUGR, an outcome more plausibly affected by maternal nutrition, health referrals, and counseling, particularly anti-smoking advice. We find a positive impact of WIC on fetal growth, though program effects are much smaller than previously estimated. We attempt to corroborate these gains with corresponding changes in maternal behaviors: smoking, weight gain, and breastfeeding. We find positive but modest effects on quitting smoking in late pregnancy and postpartum among whites and blacks, positive weight gain effects among underweight women, and positive effects on breastfeeding.

II. Background

Low birth weight (LBW; <2,500 grams) rates in the United States have changed little in the past decade, and even slightly increased from 7.9 to 8.1 percent for 2003-2004 (NCHS, 2006). The battery of health risks faced by LBW newborns includes, but is not limited to, respiratory, gastrointestinal, and immunologic problems, impeded childhood growth, and a higher chance of developing adult illnesses such as diabetes, hypertension, and cardiovascular disease (Institute of Medicine, 2007; World Health Organization, 2004). In the United States, the 2003 infant mortality rate for LBW infants was 59.4 per 1,000 live births, almost 26 times that of newborns 2,500 grams or more (NCHS, 2006).

LBW results from either preterm birth (<37 weeks of gestation), intrauterine growth retardation (IUGR), or a combination of these factors (World Health

Organization, 2004; Kramer, 1987). A substantial part of research on the prenatal WIC program has focused on discerning program impact on various birth weight measures, with the vast majority of studies finding significant, beneficial effects.

There are, however, limitations that prevent a conclusive interpretation of these findings. One is the familiar problem of selection bias. This arises when comparison groups systematically differ along hard-to-control-for characteristics, thereby biasing treatment effects. For example, if WIC mothers are more conscientious than their non-WIC counterparts, they may be more likely to have positive birth outcomes as well; WIC effects would be overestimated. It is also possible that women with a higher likelihood of negative outcomes have a greater propensity to enroll; this would cause an underestimate of WIC's impact. Strategies WIC researchers have used to lessen selection bias include using random assignment, matching, using income-eligible comparison groups, instrumental variables, and propensity score analysis.

The second limitation is that many WIC studies do not support their findings with causal pathways commonly accepted in the scientific literature. In other words how exactly does WIC work? Does it operate through preterm birth, IUGR, or both? Prominent swathes of WIC research rarely take into account the medical community's view that effective interventions for preterm birth are still largely unknown. Adjusting birth outcomes for gestation, it is claimed, will underestimate the impact of WIC because of the latter's possible influence in extending gestation – a theory for which there is scant clinical support. However, as we later discuss, there is some evidence for modest effects of nutritional interventions on IUGR. This may be an impetus to shifting the research focus on outcomes more realistically modifiable by WIC services.

Overview of Recent WIC Studies

A randomized experiment is commonly regarded as an ideal experimental design for isolating treatment effects. However, Hamilton and Rossi (2002) note that this is difficult to implement even with non-entitlement, saturation programs such as WIC. For programs nearing full saturation, it is hard to construct a plausible comparison group for whom services could be considered unavailable (Hamilton and Rossi, 2002). This difficulty is reflected in the fact that only one study has used random assignment to determine WIC's effect on birth weight. To test the impact of a WIC intervention during mid-pregnancy, Metcoff, et al. (1985) randomly assigned 410 eligible women at an Oklahoma prenatal care clinic to a WIC-supplemented group and to a control group. This experimental design was possible because the number of eligible women at the time exceeded the number of program openings. After controlling for gestational age, gender, number of prenatal visits, interpregnancy interval, smoking and having a previous LBW infant, WIC was found to have a 91-gram impact on birth weight. However, adding entry weight as a covariate – WIC mothers were heavier at entry, despite randomization – eliminated this gain, except among heavy smokers. While this suggests a possible protective effect on the fetus for high-risk mothers, the study's age, small sample size and single location make results difficult to generalize.

Some authors have used matching to construct plausible comparison groups. Kotelchuck, et al. (1984) compared birth outcomes for 4,126 WIC participants who gave birth in Massachusetts in 1978 with matching non-participants. The women were matched on age, race, parity, education, and marital status. Overall, researchers associated WIC with a 1.8 percentage point decrease in the rate of LBW, a 21-gram difference in birth weight, a 2.1-day increase in gestation, and a 1.3 percentage point decline in preterm births. The absolute values of these effects were larger among teenagers, Hispanics, and unmarried women. There was, however, no impact on either gestation-adjusted birth weight or the overall rate of SGA.

To explore a possible dose-response effect of WIC, the researchers also stratified the sample based on duration of participation. Duration was defined two ways. The first was by number of months on WIC, i.e. 1-3, 4-6, and 7-9 months. The strongest WIC effects were observed for women who spent 7-9 months in the program. Results for this group include a 111-gram difference in birth weight, a 4.9-day increase in gestation, and percentage point reductions of 5.2, 5.3, and 2.1 for LBW, preterm, and SGA, respectively. The second method of stratifying by duration was gestation-based, the percentage of pregnancy spent on WIC: 0-40%, 41-70%, and 71-100%. There was a 50-gram birth weight difference in the latter group and a 2.7 percentage point difference in the rate of LBW. There were no significant differences for gestation, preterm, or SGA.

Stockbauer (1987) also used matching in a 1982 study of 9,411 Missouri WIC participants. Matches were made on age, education, marital status, gravidity, plurality, and infant's race. Additional controls for variables on which treatment and control groups still differed, i.e. pre-pregnancy weight, smoking during pregnancy, and region of residency, did not alter results. WIC was associated with a 16% and 27% decline in LBW and VLBW, respectively. Preterm births were 22% lower. However, there was no difference in mean birth weight or SGA. When participants were stratified based on duration of participation, the authors found that only those who participated for at least seven months saw any birth weight gain (50 grams) or a reduction in LBW (18%). It should be noted that in both Stockbauer (1987) and Kotelchuck, et al. (1984), controls were limited to what was available on birth certificates; both studies were therefore unable to account for other key variables such as income or receipt of services like Medicaid.

In the National WIC Evaluation, Rush, et al. (1988) examined more than 11 million births in 19 states over 1972-1980. Data files were largely constructed from birth certificates, which did not have information on individual WIC participation. In lieu of a binary participation indicator, the authors regressed birth outcomes on the WIC penetration rate at the county level. There was a modest 23-gram gain in birth weight for each pregnant woman served; among less-educated and more-educated whites, the gains were 47 and 44 grams. Less- and more-educated blacks gained 26 and 37 grams in birth weight, respectively. There was no significant overall reduction in LBW.

Devaney, et al. (1992) employed what is now a commonly used comparison group: Medicaid participants, all adjunctively eligible for WIC, but chose not to enroll. The authors looked at nearly 105,000 Medicaid-financed births for five states in 1987 (FL, MN, NC, SC) and 1988 (TX). They found WIC effects ranging from 51-117 grams for birth weight, reductions in LBW of 2.2-5.1 percentage points, increases in gestation of 1.8-5.3 days, and declines in preterm birth of 2.3-6.3 percentage points. However, the birth weight gains fell considerably when gestation was added to the specification; estimates included a statistically insignificant -5 grams in Minnesota, 32 grams in North Carolina, and an insignificant 47 grams in South Carolina.

In an attempt to encapsulate WIC program benefits, the General Accounting Office in 1992 surveyed what was by then a substantial body of work on the program.

Based on statistically combining results from 17 studies (including those described above) on birth outcomes, the GAO determined that prenatal WIC cut down rates of LBW by 25% and VLBW by 44%. The GAO then concluded that each federal dollar invested in prenatal WIC returned $2.89 in the infant's first year, and $3.50 over 18 years in discounted present value. These conclusions are still widely cited to this day, and are largely why "WIC works" has been commonly accepted wisdom.

However, the USDA pointed out some concerns with the GAO analysis. One is that the 17 studies used data from 1982-1988; both Medicaid and WIC had changed substantially by the time the GAO issued its report. Second, most of the studies were limited to one state. Furthermore, the GAO did not sufficiently point out limitations posed by issues of selection bias (Fox, et al., 2004).

Since the GAO report, many more analyses of prenatal WIC have been published, with the majority concurring with pre-1993 findings. Gordon and Nelson (1995) looked at the 1988 National Maternal and Infant Health survey, a national sample of 9,953 women who had a live birth in 1988. The authors used income-eligible non-participants as a comparison group. Results from their basic model include a 68-gram increase in birth weight, a 3-day gain in gestation, and reductions in LBW and preterm of 2.9 and 3.6 percentage points. When gestational age is controlled for, the birth weight gain declines to a statistically insignificant 25 grams.

Brien and Swann (2001) also used NMIHS data. Their two specifications yielded unstable results. The authors first used instrumental variables and limited the sample to non-Hispanic blacks and non-Hispanic whites. In modeling the participation decision, the authors used state-level variations in program rules (e.g. ease of income verification, adjunctive eligibility for AFDC recipients), availability of WIC clinics, and generosity of other welfare programs as instruments. They found no statistically significant effects for whites on either log birth weight or log LBW. For blacks, there was a 13% increase in birth weight, but no impact on the probability of LBW. The authors also estimated a fixed-effects model, using women who had an infant prior to the NMIHS birth, to see whether changes in a woman's WIC participation status are related to differences in birth outcomes. This specification assumes that unobserved differences between WIC and non-WIC women are mother-specific and time-invariant. Results showed negative though insignificant effects for whites, a 5% increase in birth weight for blacks, and a 4.5% decrease in the probability of LBW.

Kowaleski-Jones and Duncan (2002) also employed fixed-effects estimation in comparing sibling differences in birth weight with changes in the mother's participation. Their sample consisted of children born to respondents of the National Longitudinal Survey of Youth (NLSY). While there was a large birth weight effect of 185 grams, this result is again difficult to generalize as it was based on only 71 discordant-siblings pairs.

Lazariu-Bauer, et al. (2004) drew on linked administrative and birth certificate files in New York State in 1995 and restricted the sample to WIC participants. In lieu of using a comparison group of non-participants, the authors compared outcomes for early versus late enrollees. Propensity score analysis was used to minimize observable differences between the two groups. Results showed a birth weight gain of 70 grams for full-term infants and 129 grams for preterm infants.

Bitler and Currie (2005) used the Pregnancy Risk Assessment Monitoring System (PRAMS), a mail/telephone survey of new mothers in 19 states over 1992-1999. The survey provided a rich set of controls, including education, age, infant gender, marital status, BMI, smoking, father's information on the birth certificate, parity, race/ethnicity, and region of residence. The comparison group was non-WIC women whose births were paid for by Medicaid. The estimated birth weight gain was 64 grams, gestation was 2 days more, and the declines in preterm birth and LBW were 29% and 27%. There was also a favorable, though smaller, 13% decline in SGA.

In a departure from previous approaches, Joyce, et al. (2005) instead assumed that associations between WIC and gestation are spurious and indicative of omitted variable bias. They focused on fetal growth, arguing that it is more likely to be affected by WIC services. The authors had data on 800,000 Medicaid-financed births in New York City in 1988-2001. In an attempt to lessen heterogeneity, the sample was further narrowed to women who had no previous live births and who sought early prenatal care. There were WIC effects on SGA or term LBW; the impact on gestation-adjusted birth weight was -6.3 grams. An additional analysis limited to twin deliveries found positive effects on gestation-adjusted birth weight (57 grams) and SGA (4.1 percentage point reduction), but these were limited to U.S.-born blacks. The authors concluded that results were too inconsistent to infer a causal relationship.

In their review of WIC research, Besharov and Germanis (2000) similarly noted that the program probably has modest impacts at best, citing the paucity of clinical evidence to credit nutritional supplementation with large improvements in birth weight. Further, given that selection and simultaneity bias continue to plague research designs, claims of WIC's effectiveness are likely exaggerations. They argue that "eligibility creep" and rigid per-person spending caps have come at the expense of intensifying services, particularly nutrition counseling, to the poorest and most at-risk participants.

Clinical Evidence on Preterm and IUGR Prevention

With few exceptions, the studies described above have found dramatic WIC effects on LBW, particularly preterm births, and more modest impacts on gestation-adjusted measures. However, there is one overarching consensus in the clinical literature: effective preterm birth interventions remain elusive.

Dyson, et al. (2006) studied 2,422 pregnant women attending prenatal clinics in California who were randomly assigned to one of three treatment groups. The first group had weekly contact with a nurse, the second had daily contact, and the third had daily contact and were given devices to monitor contractions. There were no statistically significant differences in the rates of preterm or very preterm birth, even among women who had twins. Buekens and Klebanoff (2001) noted in a commentary that neither prenatal care, social support, or treatment of genital infections have proven protective against preterm birth. Ancel (2004) reviewed recent literature and also concluded that programs offering nutritional supplements or more intense prenatal care have had no impact on preterm birth. In its 2007 report, the Institute of Medicine echoed these views, noting that randomized studies in both developed and developing countries have failed to link dietary supplementation to reduction of preterm birth. The IOM concluded that information on the diagnosis, prevention, and treatment of preterm birth remains inadequate.

There is evidence that fetal growth may be more amenable to intervention. In their study of the Dutch Famine of 1944-1945, Stein and Susser (1975) sought to explore the relationship between maternal nutrition and fetal growth. Two forms of comparison were made. The first compared birth measures of exposed cohorts versus cohorts whose gestation either preceded or followed the famine. The second compared exposed cohorts to those born at the same time, but in unaffected areas. The authors constructed several birth cohorts using data from teaching hospitals in famine and non-famine areas. They concluded that the main impact of famine on birth weight was due to third-trimester exposure below a 1,500-calorie threshold. Within the stricken area, mean birth weight for infants conceived before and born during the famine was 3,338 grams. This declined by 9% for the cohort conceived before and born during the famine, and who were exposed for the third trimester. Mean birth weight then climbed 8.9% for the cohort conceived and therefore never exposed to the famine. There was no detectable effect on length of gestation.

While Stein and Susser (1975) showed birth weight effects in situations of extreme deprivation, the results may not necessarily extend to developed countries. Rush, et al. (1980) selected 768 New York City women at high risk of delivering a low birth weight infant. These women were randomly assigned to three groups: one received a high-protein supplement (in beverage form), a complement group had more balanced supplements (lower protein and fewer calories), and a third control group received routine clinic care. The Supplement group gained significantly more weight compared with the other two groups, but only among women recruited within the first four months of pregnancy. The weight gain of the complement group was not statistically different from that of the control. There were no significant differences in birth weight among the three groups. However, infants born to heavy smokers who received any beverage had birth weights comparable to infants of nonsmokers. This complements Metcoff's (1985) results, suggesting that supplementation may have a protective effect for infants of smokers. Oddly, the supplement group had the highest percentage of very premature infants (9% versus 6% and 5% for the complement and control).

In assessing the WIC-birth weight relationship, this paper follows the clinical literature in assuming WIC is unlikely to impact gestation but may affect fetal growth; an association between WIC and preterm birth may instead be indicative of omitted variable bias. Detailed information on timing of enrollment lets us confirm whether previously reported effects of WIC on birth weight and preterm births are largely due to late-term participants. The size and richness of the data allow us to estimate separate effects for different groups. We not only stratify by race/ethnicity, but also look at women at risk due to low pre-pregnancy weight, multiple gestations, and smoking. Further, we can examine if WIC influences behaviors such as smoking, weight gain, and breastfeeding and thereby corroborate results for birth outcomes, something which even the methodologically stronger studies – e.g. Lazariu-Bauer, et al. (2004) – have been unable to do.

III. Data

Data are from the Pregnancy Nutrition Surveillance System (PNSS), a public health monitoring system overseen by the Centers for Disease Control and Prevention (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.

The CDC then determines the distribution of demographic, maternal health, and infant health indicators. State-level and national reports are published annually. The CDC also assesses if data are missing, miscoded, or biologically implausible; data quality reports are sent to participating states as well. [1]

Table 1 contains a list of the main indicators compiled by the PNSS; as we describe later, the quality of reporting on some of these variables varies across states. At a woman's initial WIC interview, counselors collect information on socio-demographic characteristics (e.g. race/ethnicity, age, years of education, marital status, Medicaid, AFDC/TANF or Food Stamps enrollment) and maternal health (e.g. pregravid smoking, pregnancy smoking, pre-pregnancy BMI, parity, timing of prenatal care). At the postpartum visit, information on infant birth outcomes (e.g. birth weight, gestational age) and additional maternal health behaviors (e.g. postpartum smoking, breastfeeding) are

[1] http://www.cdc.gov/pednss/what_is/pnss/what_data.htm

included. In North Carolina, records are linked to birth certificates, which provide supporting indicators on birth outcomes and maternal characteristics.

State participation in PNSS is voluntary; currently, only 22 states and three tribal governments submit records to the CDC. Our initial database contains 4,615,284 PNSS records from ten states: 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. Table 2 shows the states and the years for which records were originally available.

The process of retaining records for the final sample began with choosing years and states with credible prenatal WIC enrollment distributions and participation levels. Table 3, Panel A is a useful point of comparison. Culled from reports generated by the Food and Nutrition Service of the U.S. Department of Agriculture, it is based on a "near-census" of WIC participants. In each of the periods, more than 86% of prenatal WIC participants were already signed up by the second trimester of their pregnancies (USDA, 2004).

PNSS tabulations in Panel B, however, show that in Illinois, 72-84% of prenatal women purportedly do not enlist until the third trimester. Based on the USDA distributions, we therefore assume that Illinois enrollment data may be incomplete and exclude the state from analyses. We also dropped additional years in states for which distributions are similarly suspect. Because Michigan prenatal enrollment in 1995 consists of 88% unknowns, 1995 data for this state are dropped. Also excluded are Florida years 1995-1996, 1998, and 2000-2001, which have high proportions of unknowns (26-98%).

Some state-years with reasonable distributions have inexplicably volatile enrollment levels. In Florida, prenatal registration numbers plunge 30% from 1996 to 1997, then recover by 233% from 1997 to 1999. Indiana, New Jersey and Ohio records for 2000, 1997-1999, and 1998, respectively, exhibit similarly inconsistent enrollment levels. . To test the sensitivity of results, we do estimate a few key outcomes that include these state-years, while excluding them from most of our regressions.

We also had to drop prenatal enrollees who failed to return for a WIC postpartum interview. Data on birth outcomes, breastfeeding, postpartum smoking and even plurality of birth are obtained during the postpartum visit and would therefore be unavailable for women lost to follow-up. The exception would be North Carolina, which links its WIC administrative data to birth certificates, making birth outcomes available for women who did not re-certify. While it is difficult to determine exactly how excluding lost to follow-up women biases our results, some insight can be obtained by estimating a separate set of birth outcomes for NC that includes these women. Our primary results, however, are based on prenatal women who have complete records (both WIC interviews), and postpartum-only enrollees.

Table 4 compares characteristics of lost to follow-up enrollees with prenatal and postpartum registrants. Women lost to follow-up have similar age, marital status, education, and poverty distributions compared to registrants with complete records. The former have proportionally fewer Non-Hispanic whites and roughly the same percentage of Hispanics. Pre-pregnancy BMI, pregravid smoking, and information on other types of public assistance are much more poorly reported.

We further limit our remaining prenatal sample to women who sign up for WIC five weeks or more into their pregnancies. This eliminates a small group of women (30,675 after dropping lost to follow-ups and state-years mentioned earlier); in doing so, we assume that there may be some measurement error in determining gestational age. The latter is based on the date of the last menstrual period. Because the first missed period is typically not detected until four 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.

Some birth outcomes cannot be measured for certain groups. We are unable to estimate preterm and fetal growth effects for women who are missing gestational age information. Gestation data are incomplete for Michigan, postpartum Virginia enrollees, and postpartum New Jersey women. Figures 1.a-1.c show gestational age distributions for all states, along with separate distributions for Michigan and Virginia. Close to 100% of Michigan women and all postpartum Virginia women are marked as having gestations of exactly 40 weeks. This implies that there are zero preterm births among these women, an unrealistic outcome and perhaps indicative of data collection or input problems. Furthermore, ninety-nine percent of NJ postpartum women are missing gestational age information. We hence reset gestation to missing for Michigan, postpartum Virginia enrollees, and postpartum New Jersey women. In addition, one measure of fetal growth, small-for-gestational-age (SGA), relies on knowledge of both gestation and infant gender. The latter is unknown for all Georgia and Virginia enrollees; SGA effects cannot be obtained for any women in these states.

Table 5 shows the composition of the final sample by state. Except for New Jersey and Virginia, which have the smallest shares of the sample at 5.9% and 1.4%, enrollments are almost evenly distributed among the remaining states. Michigan has the largest share of enrollees at 17%, followed by Missouri (14.5%), North Carolina (14%), Ohio (13.6%), Indiana (11.7%), Georgia (11%), and Florida (10.7%). Table 6 shows the unbalanced panel, with ten years (1995-2004) and nine states. More than half of observations are from 2001-2004; 1995 only has data from two states, Indiana and Missouri.

Table 7 juxtaposes characteristics of pregnant enrollees in our sample with USDA tabulations. Age and poverty distributions are similar. Prenatal enrollees in the PNSS sample have proportionally more Non-Hispanic whites and third-trimester enrollees. Table 8 contains state-specific comparisons between PNSS and USDA birth weights and maternal weight gains; in general, means are also similar.

Characteristics of the final sample of singleton-birth mothers by timing of WIC registration are shown in Table 9. Compared with postpartum enrollees, prenatal women are more likely to be Non-Hispanic whites, teens, unmarried, have less than 12 years of schooling, have zero parity, and be on other types of public assistance; most differences are statistically significant due to the large samples. In general, differences among prenatal women are smaller, as are differences between late enrollees and postpartum women.

Table 10 shows the same characteristics on a state-by-state basis. The quality of reporting for several variables differs across states. Parity is well-reported for most but is missing all values for Georgia and postpartum Virginia, and is poorly reported for postpartum Indiana. Pre-pregnancy BMI is poorly reported for all states except Missouri. Smoking before pregnancy is another variable where coverage varies: in most states, there are large proportions of unknowns for postpartum women. Marital status is unknown for all Virginia women and is poorly reported for postpartum Indiana and postpartum New Jersey. Race/ethnicity, mother's age, and education (except for Indiana) are well-reported.

Who tends to enroll prenatally varies across states. In Florida, Georgia, Indiana, North Carolina, Ohio, and Virginia, race/ethnicity distributions are similar for prenatal and postpartum women. In Michigan, Missouri, and New Jersey, prenatal enrollees have proportionally fewer Non-Hispanic blacks compared with postpartum women. Except in Georgia, prenatal registrants are more likely to be teenagers. Prenatal women have larger proportions of high-school drop-outs, though the differences are small (2-4.5 percentage points) in most states.

Smoking Information

We are able to construct smoking measures for three periods: pre-pregnancy, during pregnancy, and postpartum. Our procedures for assigning smoking status before pregnancy, during pregnancy, and postpartum slightly differ for North Carolina. This is because: (1) WIC records in the state are linked to birth certificates, which have additional smoking questions, and; (2) at the postpartum visit, there is only one smoking question (a "change" variable, described below), which is interpreted differently by North Carolina authorities.

Pre-pregnancy Smoking

Except for North Carolina, pregravid smoking status is based on two questions: (1) average number of cigarettes smoked per day three months before pregnancy, and (2) a "change" variable indicating if the woman has decreased smoking from pre-pregnancy to pregnancy. These questions are asked at the WIC prenatal interview. The "change" variable is not dichotomous, but a multiple-choice indicator that allow mothers to choose among responses such as "Smokes fewer cigarettes than before pregnancy," "Stopped smoking after becoming pregnant," or "Non-smoker," among others. Buescher (1997) writes that inclusion of partially favorable answers increases smoking disclosure by pregnant women. 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. Women who were initially counted as pregravid nonsmokers but are smokers during pregnancy are also reclassified as pregravid smokers. These reclassified women are less than one percent of total pregravid smokers. (Not reclassifying does not significantly change results.)

For North Carolina, 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. Postpartum registrants in North Carolina are only asked the postpartum "change" question above. We use this variable to infer pregravid smoking by women who register for WIC only after giving birth.

Smoking During Pregnancy

For states other than NC, 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) average number of cigarettes smoked during the last three months of pregnancy. The first two questions are asked at the prenatal interview, the third at postpartum.

For NC, 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.

Postpartum smoking

For states other than NC, postpartum smoking is based on: (1) current number of cigarettes smoked per day, and; (2) a "change" variable indicating if the woman decreased smoking from birth to the postpartum visit. For NC, postpartum smoking is based on the only smoking question asked of postpartum registrants: the "change" variable for smoking from pregravid to postpartum.

An important limitation of our data is inconsistent smoking reporting across states. Pre-pregnancy smoking is unknown for all prenatal and postpartum Georgia participants, postpartum Florida, and postpartum Virginia; there are also large proportions of unknowns for Michigan and New Jersey. Pregnancy smoking is much better reported overall, though it is unknown for postpartum Georgia women and virtually all postpartum Florida women. Postpartum smoking is unknown for both all Florida enrollees and has large proportions of unknowns for Indiana and Michigan. All smoking measures are well-reported for Missouri, North Carolina, and Ohio. Table 11 shows how 1995-2001 pregnancy smoking rates from the NCHS's Vital Statistics Birth Cohort Linked Birth/Infant Death Data compare with PNSS. Smoking rates – excluding unknowns -- for our final samples of singleton births are, as expected, larger than NCHS rates. However, limiting the comparison to unmarried women with 12 or fewer years of education considerably narrows the differences in most states. (Florida and Virginia are not included in the comparison because final samples for these states do not include 1995-2001.)

IV. Empirical Model and Outcomes

The typical model in WIC evaluations is

(1) $$H = \alpha_0 + \alpha_1 WIC + X\beta + e.$$

H represents a birth or maternal outcome such as birth weight or breastfeeding. The variable WIC is a dichotomous indicator of whether or not a woman enlisted in WIC during pregnancy. The comparison group consists of eligible non-participants. (Because Medicaid beneficiaries are adjunctively eligible for WIC, comparison groups have frequently been drawn from Medicaid populations.) X is a matrix of other relevant variables, including characteristics of the mother such as race/ethnicity, age, marital status, pre-pregnancy BMI, parity, poverty level, participation in Medicaid/TANF/Food Stamps, year of infant's birth, and state of residence. Let e be the error term. For desirable outcomes such as birth weight in grams, we expect $\alpha_1 > 0$ and the reverse for adverse outcomes such as whether or not an infant is of low birth weight.

Selection or omitted variable bias exists when unobserved characteristics systematically sort individuals into participant and non-participant groups. In the case of adverse selection, women prone to have unhealthy pregnancies or engage in detrimental behaviors such as smoking may be more likely to seek WIC services. In this scenario, WIC's impact will be underestimated. Positive selection is also possible; highly motivated, conscientious women may be more prone to enroll in WIC, inflating its estimated benefits.

The WIC coefficient α_1 from Equation (1) measures the program's impact on prenatal participants, or the average effect of treatment on the treated, under two assumptions. First, conditional on X, outcomes for non-participants are independent of the participation decision. Second, the treatment effect is constant across individuals (Wooldridge, 2002). These are strong assumptions; in reality, there are likely to be differences in the pre-treatment states between participants and non-participants. That is, selection or omitted variable bias exists when unobserved characteristics systematically sort individuals into participant and non-participant groups. In the case of adverse selection, women prone to have unhealthy pregnancies or engage in detrimental behaviors such as smoking may be more likely to seek WIC services. In this scenario, WIC's impact will be underestimated. Positive selection is also possible; highly motivated, conscientious women may be more prone to enroll in WIC, inflating its estimated benefits.

A popular method for dealing with selection bias has been the instrumental variable procedure. Viable instruments, however, need to be uncorrelated with the error term but highly correlated with the covariate of interest (WIC). In the absence of such instruments for our sample, we instead have a rich set of controls to mitigate selection bias, as well as a large number of observations that allows us to stratify the sample into more homogeneous groups. We have estimates by race/ethnicity, by pregnancy risk factor (underweight, pregravid smoker, multiple gestations), and whether a woman is on her first birth and sought prenatal care in her first trimester. The latter is a group of women motivated enough to seek early care but have had no previous experience with WIC and whose enrollments could not have been influenced by earlier pregnancy outcomes.

Information on the timing of WIC enrollment lets us expand the model as follows:

$$H = \alpha_0 + \alpha_1 WIC_1 + \alpha_2 WIC_2 + \alpha_3 WIC_3 + X\beta + e. \quad (2)$$

The WIC variables indicate the trimester of pregnancy a woman joined the program. If lengthier WIC exposure is more beneficial, we should expect $\alpha_1 > \alpha_2 > \alpha_3 > 0$ for desirable outcomes and the reverse for negative outcomes. Our omitted group, in lieu of eligible non-participants, consists of women who do not sign up for WIC until the postpartum period. Thus we compare prenatal participants to women who are not just eligible, but who know of WIC and have elected to enroll. However, for comparability with previous studies which have used Medicaid non-participants as comparison groups (Buescher, et al. 1993; Devaney, Bilheimer and Schore, 1992; Bitler and Currie, 2005), we also show separate estimates for prenatal and postpartum WIC women who were also Medicaid beneficiaries.

For continuous outcomes such as birth weight in grams, we estimate equations (1) and (2) using ordinary least squares. For dichotomous outcomes, we use maximum-likelihood probit and report marginal effects (for our case, the effect when WIC changes from 0 to 1) for an average participant. We adjust standard errors (using Stata's cluster() option) for clustering at the state-year level. We also present separate results for North Carolina. There are only eight years of data, so in lieu of the cluster() procedure, we first regress outcomes on X and year dummies. Residuals are then aggregated by year and WIC participation, then regressed on the year and WIC dummies, weighting regressions by the number of births per cell. [2]

Propensity score methods

Another approach to selection bias attempts to "balance" characteristics between participant and non-participant groups using propensity scores – that is, the probability of an individual's initially enrolling in prenatal instead of postpartum WIC. Following Hirano and Imbens (2001), we obtain a woman's propensity score (PSi) by regressing a WIC participation variable on all relevant covariates. We then run weighted regressions of birth weight outcomes on WIC and the full set of covariates, with weights equaling 1 for all prenatal women and (PSi)/(1-PSi) for postpartum enrollees. This method assumes treatment assignment is unconfounded with potential outcomes (Hirano and Imbens, 2001). If the selection bias is driven by unobservables uncorrelated with the controls, propensity score methods will still fail to identify WIC's effect.

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[2] See Joyce, et al. (2008).

Dependent variables

We estimate WIC's impact on two groups of birth weight measures: those that are unadjusted for gestation and gestation-adjusted outcomes. The first group includes birth weight in grams, and dichotomous indicators of LBW, VLBW, and preterm. We estimate WIC coefficients for this group to establish comparability with previous studies as well as to show the difficulty of isolating WIC effects from gestational age bias. The second set of outcomes includes birth weight adjusted for gestation (i.e. gestation is included among the independent variables), and dichotomous indicators of whether an infant is full-term LBW ($\geq$37 weeks and <2500 grams) or small for gestational age (birth weight below the 10th percentile given gestational age; see Alexander (1998)). These measures serve as proxies for intrauterine growth retardation, an outcome which is more likely to be influenced by supplementation, changes in smoking, and maternal weight gain.

We also estimate WIC's effect on four indicators of maternal health: change in smoking from pre-pregnancy to postpartum, change in smoking from pre-pregnancy to the third trimester, maternal weight gain, and breastfeeding. If WIC positively impacts birth weight, we should detect a corresponding change in maternal behavior.

V. Results

Tables 12 & 13 show results for outcomes unadjusted for gestation. The first row in Table 12 contains estimates of α_1 from Equation (1); the succeeding rows show estimates of α_1, α_2, and $\alpha_3$from Equation (2). For each outcome, we estimate coefficients for all women, as well as for the subset of Medicaid participants. By showing results for the latter group, we attempt to compare our estimates with other WIC studies which have drawn their samples from Medicaid populations (Devaney, et al. (1992), Bitler and Currie (2005)). Estimates for birth weight are obtained by ordinary least squares; maximum likelihood probit is used for dichotomous outcomes.

Our estimates of α_1 from Equation (1) associate WIC with 59- and 62-gram increases in birth weight for all women and for the Medicaid subgroup, respectively. These numbers are similar to those from previous research. In their five-state study, Devaney, et al. (1992) associated WIC with an increase in birth weight ranging from 51 grams in Minnesota to 117 grams in North Carolina. Bitler and Currie (2005) calculated a 63-gram increase in birth weight due to WIC.

Estimates are similar for all women and for the Medicaid subgroup; prenatal WIC is associated with 2.5 and 2.7 percentage point decreases in the rate of LBW, respectively. These translate into 32-34 percent declines based on the regression sample means. The results for VLBW and preterm are also dramatic: an 80-82 percent decline in VLBW and 22-24 percent for preterm. Bitler and Currie (2005) associated WIC with a 27 percent decline in the rate of LBW; estimates for VLBW and preterm were 54 and 29 percent.

Estimates by the trimester of WIC enrollment, however, show that a significant portion of WIC's effects accrue to third-trimester enrollees. Third-trimester participants experience greater increases in birth weight and more sizeable declines in LBW, VLBW, and preterm, compared with first-trimester participants. These results are consistent across all outcomes in Table 12. Among all women, third-trimester enrollees have rates of LBW and preterm birth that are lower by 1.1 and 4.6 percentage points compared with first-trimester participants.

The third-trimester advantage persists in Table 13, where we show results by race/ethnicity. The seemingly counterintuitive pattern of $|\alpha_3|>|\alpha_1|$ in part reflects the effect of gestational age bias – i.e. women who tend to enroll in the third trimester already have longer and healthier pregnancies for reasons unrelated to WIC. Longer pregnancies also afford a greater opportunity to sign up; women who would have enrolled but instead gave birth prematurely may therefore be part of the postpartum cohort, pushing up rates of adverse outcomes for this group. Figure 2 bears this out, showing the rates of LBW and preterm by the week of pregnancy in which a woman enrolled in prenatal WIC; rates for postpartum women are also shown. The later a woman enrolls, the smaller the likelihood of an adverse birth outcome. The rates of LBW and preterm for postpartum women are also clearly elevated over most of the prenatal cohort.

Because of the clinical consensus that effective preterm birth interventions remain unknown (Institute of Medicine, 2007) and the difficulty of removing gestational age bias for outcomes largely determined by pregnancy duration, it is more appropriate to estimate WIC effects for gestation-adjusted measures. Table 14 shows results for three such outcomes: birth weight with gestation added as an independent regression variable; a dichotomous indicator for whether an infant is small for gestational age (SGA); and a dichotomous indicator for whether an infant is full term, low birth weight (FTLBW; $\geq$37 weeks and <2,500 grams). Results are shown for all women as well as by race/ethnicity. Earlier WIC enrollment is associated with better birth outcomes, though the impacts are much smaller. Prenatal WIC raises birth weight by 39 grams; the gains are 30, 49, and 56 grams for whites, blacks, and Hispanics. Birth weights for first trimester women exceed those of third-trimester enrollees by 13 grams. Prenatal WIC is associated with a 1.6 percentage point decline in the probability of an SGA birth – an 11 percent decrease based on the sample mean. Declines in SGA are greater for blacks and Hispanics compared with whites. There is no first over third trimester advantage for white women. Prenatal WIC is associated with just a 0.7 percentage point decrease in the rate of FTLBW. Percentage point declines are again greater for blacks and Hispanics compared with whites.

Table 15 shows estimates of WIC coefficients for three at-risk groups of women: those who were underweight pre-pregnancy, pregravid smokers, and women with multiple gestations. The pattern of results is similar to that in Table 14. Prenatal WIC is associated with a 32-gram increase in birth weight among underweight women, a 42-gram increase among smokers, and 53 grams among women with multiple gestations. SGA also declines, though the prenatal WIC coefficient is insignificant for multiple gestations. Prenatal WIC also reduces the rate of FTLBW, though there is no first over third trimester advantage within any of the at-risk groups.

Table 16 again shows results for gestation-unadjusted outcomes and fetal growth proxies, but only for women of parity zero and who sought prenatal care in the first trimester. For gestation-unadjusted outcomes, gains to WIC are greater for this group of women compared with the larger sample. Prenatal WIC is associated with a 62-gram increase in birth weight and 3.1, 1.2, and 3.3 percentage point declines in LBW, VLBW, and preterm. Gains in fetal growth are smaller, though: a 25-gram increase in birth weight and 0.8 and 0.6 percentage point decreases in rates of SGA and FTLBW.

These tables indicate that once gestation is controlled for, WIC's effect is smaller than previously estimated. This is consistent with previous studies that find large effects on preterm and LBW, but find smaller effects for fetal growth proxies (see Bitler and Currie (2005), Joyce, et al. (2005), Gordon and Nelson (1995), Stockbauer (1987)). Figure 3 supports these outcomes. It is similar to Figure 2; rates of SGA and FTLBW are shown by the week of pregnancy when a woman enrolled in prenatal WIC. From week 11 to week 33, the lines are almost flat, indicating that there is little advantage to early versus late enrollment. The findings of Black, et al. (2007), who looked at same-sex twin pairs born in Norway from 1967-1997, help put such results in context. The researchers were able to link birth records to administrative data and link birth weight to long-run labor market outcomes. A 280-gram, gestation-adjusted increase in birth weight was associated with raising the probability of completing high school by 1 percentage point, IQ by 1/20th of a stanine and earnings by 1 percent. Our estimates are about 1/7th as large; if WIC does have long-term effects, they are modest.

In an attempt to corroborate the gains to fetal growth from prenatal WIC, we next test program impact on four measures of maternal health and behavior: (1) if a pregravid smoker quit smoking in the last 3 months of pregnancy; (2) if a pregravid smoker quit smoking postpartum; (3) if a woman ever breastfed; and (4) pregnancy weight gain. Results are in Table 17. Because pregravid smoking is poorly reported among postpartum enrollees, we compare first and second-trimester women with third-trimester enrollees for (1) and (2) above. For (1), we show results with and without North Carolina; this state did not have a variable for smoking during the last 3 months of pregnancy. For regressions that included NC, we used the birth certificate smoking indicator ("smoked during pregnancy") as a proxy. Dropping NC from the sample does not change results significantly. Enrolling in WIC in the first instead of the third trimester increases the probability of quitting by 1.4-1.7 percentage points. The gains are largest among blacks, whose quit rates increase by 3.8-4.1 percentage points. Results for Hispanics are insignificant.

For postpartum quits, we include estimates with and without adjustments for the time from birth to postpartum certification. Overall results are also modest, with first-trimester WIC increasing postpartum quitting by just 0.8-1.0 percentage point compared with the third trimester. However, gains for blacks are comparatively large; quit rates are larger by 3.2-3.6 percentage points. Results for Hispanics are again insignificant.

For breastfeeding initiation, we also show estimates with and without adjustments for the time from birth to postpartum certification. Compared with postpartum women, prenatal women's breastfeeding rates are higher by 2.4-2.5 percentage points, with first trimester enrollees' rates exceeding later enrollees'. Across all racial/ethnic groups, first trimester women are more likely to breastfeed.

We show results for pregnancy weight gain for all women and for women who were underweight pre-pregnancy. Odd-numbered columns show results further adjusted for gestation. Only among underweight women is WIC associated with weight gain; prenatal women gain 0.6 lb compared to their postpartum counterparts. This advantage disappears, however, when one adjusts for gestation – overall, there is no weight gain advantage for prenatal WIC; broken down by trimester, only first-trimester enrollees gain relative to postpartum women.

North Carolina

We present separate estimates for North Carolina in Table 18 to assess the likely impact of excluding lost-to-follow-up women – that is, women who enrolled prenatally but did not return for a postpartum visit. If these women have better outcomes on average, WIC's effect will be understated, and vice-versa. We look at all birth weight measures, both adjusted and unadjusted for gestation. We also estimate WIC's impact on smoking during pregnancy based on the birth certificate question. Odd-numbered columns include all women; even-numbered columns exclude those lost to follow-up. Estimates for each group are nearly identical. Further, the patterns of results follow that of the larger sample, though for NC the absolute values of coefficients are larger for outcomes unadjusted for gestation and smaller for gestation-adjusted outcomes. Given that lost-to-follow-up women have worse outcomes than women with complete records (see Table 19), it is probable that excluding lost women from the larger sample has either had a negligible effect or has led to overestimates of the coefficients' absolute values.

Propensity Score Matching

Table 20 has results from propensity score matching. We limit estimates to fetal growth proxies and maternal behavior. There is little difference between these results and those shown in Tables 14 and 17. After "balancing" on observables, WIC is associated with a 46-gram increase in birth weight and a 1.9 and 0.8 percentage point decline in

SGA and FTLBW. Compared with third-trimester women, first-trimester enrollees are 3 and 2.7 percent more likely to quit by the last three months of pregnancy and postpartum, respectively.

VI. Conclusion

With a rich dataset that allows us to more precisely control for the timing of WIC enrollment, we are able to show that effects are larger the longer women delay participation. Large WIC effects estimated by earlier studies, and which we were able to duplicate, can be attributed to women already having lengthier, healthier pregnancies when they sign up. When we estimate effects on fetal growth proxies, we do find positive gains, though the magnitudes are much smaller.

While WIC is positively associated with breastfeeding, effects on behaviors that directly affect fetal growth are inconsistent. The impact on late-pregnancy smoking is modest and, among Hispanics, is insignificant. In a clinical trial of smoking and its impact on birth weight, Sexton and Hebel (1984) found that pregnant smokers in an enhanced smoking cessation program had a 43 percent quit rate by the 8^{th} month, compared with 20 percent for the control group. Birth weights for the treatment group were 92 grams greater on average. The 1.7 percentage point difference in late-pregnancy smoking between early and late enrollees in our sample is therefore likely to only have a very modest impact on birth outcomes. Similarly, while WIC has a positive effect on weight gain, the magnitudes are modest (less than 0.75 lb) and are significant only among underweight women.

The WIC debate has for too long implied that the program's continued existence relies on its impact on birth outcomes. This is unrealistic, as well as too narrowly focused, given that much remains unknown about preterm birth. However, the popularity of WIC (over 8 million monthly participants) indicates that, given more flexibility, it may potentially impact the long-term health of families by intensively pursuing smoking interventions as well as combating obesity – a growing problem among lower-income populations - through education and tailoring food packages.

Table 1. Data Collected and Analyzed by the PNSS	
Demographic Indicators	Source of data (WIC, MCH, etc), race/ethnicity, woman's age, education, % poverty level, program participation and migrant status
Maternal Health Indicators	Prepregnancy BMI, maternal weight gain, anemia, parity, interpregnancy interval, diabetes during pregnancy and hypertension during pregnancy
Maternal Behavioral Indicators	Medical care, WIC enrollment and multivitamin consumption
Smoking/Drinking Indicators	Smoking, smoking changes, smoking in household and drinking
Infant Health Indicators	Birthweight, preterm birth, full term low birthweight and breastfeeding initiation

Reproduced from http://www.cdc.gov/pednss/what_is/pnss/what_data.htm.

Table 2. Distribution of Prenatal and Postpartum WIC Enrollment, Original PNSS Data

FL	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	0.0	0.7	10.3	11.9	21.1	10.3	8.7	21.0	23.4	26.8
Second trimester	0.0	0.8	10.8	13.3	30.7	15.9	14.5	35.6	35.5	35.7
Third trimester	0.0	0.3	3.2	3.8	18.8	12.1	9.8	21.4	20.5	19.0
Postpartum	9.5	15.4	65.3	69.9	27.7	20.5	22.3	22.1	20.6	18.5
Unknown	90.5	82.8	10.4	1.1	1.7	41.2	44.7	0.0	0.0	0.0
N	29,367	38,194	64,823	65,887	100,429	108,198	116,071	120,839	118,848	113,927
GA	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**				
First trimester	31.7	29.5	27.9	28.0	26.6	26.9				
Second trimester	16.9	16.0	15.0	15.4	15.3	16.3				
Third trimester	7.0	6.7	6.2	6.2	6.0	6.2				
Postpartum	44.4	47.8	50.9	50.5	52.2	50.7				
Unknown	0.0	0.0	0.0	0.0	0.0	0.0				
N	62,759	64,975	64,970	62,183	62,296	53,333				
IL	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	7.2	8.1	6.8	6.2	6.0	5.8	5.5	5.4	6.0	5.4
Second trimester	15.0	15.5	13.5	10.8	10.2	8.8	8.5	7.4	7.4	6.4
Third trimester	59.2	58.0	60.7	62.9	63.9	64.1	64.0	64.2	61.8	63.2
Postpartum	17.3	17.2	18.2	20.0	19.8	21.1	21.8	22.8	24.5	24.7
Unknown	1.3	1.1	0.8	0.2	0.2	0.2	0.2	0.2	0.3	0.2
N	73,905	73,115	70,010	76,100	76,640	78,335	79,951	79,708	84,505	79,906
IN	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	32.0	31.4	32.9	32.2	31.6	21.4	30.5	35.8	34.5	29.6
Second trimester	27.5	28.2	28.6	28.5	28.1	28.5	32.9	32.1	29.9	28.4
Third trimester	14.5	14.9	14.3	14.3	14.8	21.4	17.7	16.5	15.3	14.2
Postpartum	26.0	25.5	24.2	25.1	25.5	28.0	16.7	14.6	20.0	27.8
Unknown	0.0	0.0	0.0	0.0	0.0	0.7	2.2	1.1	0.3	0.0
N	42,447	40,129	40,274	44,274	44,229	22,257	35,282	36,319	39,179	43,837
MI	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	3.8	27.2	27.2	30.1	30.1	29.6	29.5	31.1	30.4	30.2
Second trimester	4.0	34.2	34.4	32.7	32.3	32.1	33.4	32.3	32.4	33.2
Third trimester	1.9	19.9	20.1	19.2	19.2	19.0	18.7	18.2	18.5	18.7
Postpartum	16.4	18.5	18.1	17.7	18.2	19.0	18.2	18.1	18.4	17.7
Unknown	73.9	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3
N	42,765	59,794	58,796	61,824	57,354	62,088	61,122	59,234	61,040	64,160
MO	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	37.3	38.4	39.9	38.9	39.2	39.5	38.6	41.0	40.5	40.0
Second trimester	28.0	27.4	27.4	25.8	26.7	26.2	26.4	26.2	25.6	26.2
Third trimester	13.7	13.6	13.2	12.9	13.0	13.1	13.4	13.0	12.2	12.7
Postpartum	20.6	20.4	19.2	22.2	20.8	21.0	21.3	19.5	21.3	20.7
Unknown	0.3	0.3	0.2	0.3	0.3	0.2	0.3	0.4	0.4	0.4
N	41,370	42,399	42,157	44,405	42,961	43,590	43,640	40,574	44,884	46,042
NC	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**		
First trimester	33.7	35.6	35.3	35.4	29.0	30.6	30.5	29.5		
Second trimester	34.2	33.5	33.1	31.8	33.7	34.0	34.5	34.4		
Third trimester	16.6	16.6	16.9	16.7	18.9	18.4	18.1	18.0		
Postpartum	15.3	14.1	14.5	16.0	18.3	16.9	16.8	18.1		
Unknown	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1		
N	51,235	52,633	54,593	54,123	56,338	55,913	55,870	56,523		
NJ	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**		
First trimester	27.2	27.2	11.0	21.7	21.8	22.8	20.5	20.9		
Second trimester	45.1	45.1	30.3	38.6	39.4	38.6	37.6	39.0		
Third trimester	25.6	21.8	20.1	20.9	21.4	20.3	18.7	18.4		
Postpartum	1.3	5.8	37.4	18.4	16.2	17.1	21.6	20.0		
Unknown	0.8	0.2	1.3	0.5	1.2	1.2	1.6	1.7		
N	25,659	22,700	28,195	39,511	39,358	40,452	44,702	44,025		

Table 2, Continued. Distribution of Prenatal and Postpartum WIC Enrollment, Original PNSS Data

OH	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	28.1	30.5	30.9	30.1	31.1	31.3	32.9
Second trimester	33.6	32.7	31.9	32.3	32.2	32.4	33.1
Third trimester	24.6	20.4	20.3	20.5	20.3	20.4	20.0
Postpartum	13.8	16.4	16.8	17.2	16.4	15.9	14.0
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N	9,126	67,071	69,950	68,327	69,065	69,284	68,826
VA	**2004**						
First trimester	27.1						
Second trimester	33.3						
Third trimester	16.5						
Postpartum	23.0						
Unknown	0.0						
N	44,105						

Table 3.A. Distribution of Prenatal WIC Enrollment, USDA

National	April 2000	April 2002+	April 2004
First trimester	47.7	48.4	50.7
Second trimester	39.0	39.8	38.4
Third trimester	11.7	10.6	9.7
Not reported	1.6	1.3	1.2
N	898,210	878,619	940,514

Table 3.B. Distribution of Prenatal WIC Enrollment, Original PNSS Data

FL	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	0.8	29.6	39.5	22.3	29.2	12.9	11.2	26.9	29.4	32.9
Second trimester	0.9	31.1	44.2	32.8	42.5	20.0	18.6	45.6	44.7	43.8
Third trimester	0.3	9.3	12.8	19.0	25.9	15.2	12.7	27.5	25.8	23.3
Unknown	97.9	30.0	3.5	26.0	2.4	51.9	57.6	0.0	0.0	0.0
N	26,580	32,303	22,505	19,848	72,635	86,050	90,139	94,184	94,325	92,820
GA	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**				
First trimester	57.1	56.5	56.7	56.5	55.7	54.5				
Second trimester	30.3	30.6	30.6	31.1	31.9	33.0				
Third trimester	12.6	12.9	12.6	12.4	12.4	12.5				
Unknown	0.0	0.0	0.0	0.0	0.0	0.0				
N	34,866	33,934	31,894	30,813	29,806	26,321				
IL	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	8.7	9.8	8.3	7.8	7.4	7.3	7.1	6.9	8.0	7.2
Second trimester	18.2	18.8	16.5	13.5	12.7	11.2	10.8	9.6	9.7	8.6
Third trimester	71.6	70.1	74.2	78.6	79.6	81.3	81.8	83.1	81.9	83.9
Unknown	1.5	1.4	1.0	0.2	0.3	0.2	0.3	0.3	0.4	0.3
N	61,089	60,513	57,285	60,901	61,453	61,836	62,545	61,534	63,770	60,153
IN	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	43.3	42.2	43.5	42.9	42.5	29.7	36.6	41.9	43.1	41.0
Second trimester	37.1	37.8	37.7	38.1	37.7	39.5	39.5	37.6	37.4	39.3
Third trimester	19.6	20.0	18.8	19.0	19.9	29.7	21.2	19.3	19.2	19.7
Unknown	0.0	0.0	0.0	0.0	0.0	1.0	2.7	1.2	0.4	0.0
N	31,418	29,899	30,517	33,179	32,947	16,035	29,390	31,031	31,358	31,644
MI	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	4.6	33.4	33.2	36.6	36.8	36.5	36.1	38.0	37.3	36.7
Second trimester	4.7	41.9	42.0	39.8	39.4	39.7	40.8	39.5	39.7	40.3
Third trimester	2.3	24.4	24.5	23.3	23.5	23.5	22.8	22.2	22.7	22.7
Unknown	88.4	0.2	0.3	0.3	0.4	0.4	0.3	0.4	0.3	0.3
N	35,774	48,710	48,185	50,854	46,939	50,323	50,023	48,503	49,784	52,795
MO	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	47.0	48.2	49.4	50.0	49.5	50.0	49.1	50.9	51.5	50.5
Second trimester	35.3	34.4	33.9	33.2	33.7	33.2	33.6	32.5	32.5	33.1
Third trimester	17.3	17.0	16.4	16.5	16.4	16.6	17.0	16.2	15.5	16.0
Unknown	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.5	0.5	0.5
N	32,834	33,763	34,048	34,569	34,044	34,437	34,355	32,655	35,325	36,523
NC	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**		
First trimester	39.7	41.4	41.3	42.1	35.5	36.8	36.6	36.0		
Second trimester	40.4	39.0	38.8	37.9	41.3	40.9	41.5	42.0		
Third trimester	19.6	19.3	19.8	19.9	23.1	22.2	21.7	22.0		
Unknown	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1		
N	43,409	45,198	46,659	45,467	46,040	46,477	46,507	46,288		
NJ	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**		
First trimester	27.5	28.9	17.5	26.5	26.0	27.4	26.2	26.1		
Second trimester	45.7	47.8	48.4	47.3	47.1	46.6	48.0	48.7		
Third trimester	26.0	23.1	32.1	25.6	25.5	24.5	23.8	23.0		
Unknown	0.9	0.2	2.0	0.6	1.4	1.5	2.1	2.1		
N	25,338	21,391	17,656	32,250	32,968	33,550	35,057	35,204		

Table 3.B, Continued. Distribution of Prenatal WIC Enrollment, Original PNSS Data

OH	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
First trimester	32.6	36.5	37.2	36.3	37.2	37.3	38.2
Second trimester	39.0	39.1	38.4	38.9	38.6	38.5	38.5
Third trimester	28.5	24.4	24.4	24.7	24.3	24.3	23.3
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N	7,870	56,085	58,179	56,592	57,726	58,241	59,181
VA	**2004**						
First trimester	35.2						
Second trimester	43.3						
Third trimester	21.5						
Unknown	0.0						
N	33,949						

+ Four WIC State agencies unable to provide sufficient data. The FNS says 104,000 participants were not tallied as a result.

Table 4. Characteristics of WIC Enrollees, By Completeness of Records				
	Prenatal WIC, Complete Records	Prenatal WIC, Lost to Follow-Up	Postpartum WIC	Total
Race/Ethnicity				
Non-Hispanic White	55.1	48.8	49.4	53
Non-Hispanic Black	28.6	32.2	32.8	30
Native American	0.6	0.6	0.4	0.5
Asian	1.1	1.5	1.7	1.3
Hispanic	13.6	15.7	14.5	14.1
Other/Unknown	1	1.3	1.2	1.1
Marital Status				
Married	32.1	28.8	37.4	32.9
Unknown	5.2	5.8	5.4	5.3
Parity				
0	45.7	44.3	39.9	44.2
1-3	44.2	52.1	25.8	39.7
4+	3.4	3.6	2.5	3.2
Unknown	6.7	0	31.8	12.9
Age				
Under 20	24.7	25	18.5	23.4
20-29	59	58.6	60.8	59.4
30 and over	16.3	16.3	20.6	17.3
Unknown	0	0	0	0
Education (Mothers >=20 years old)				
<12 years	27.4	28	24.8	26.9
12 years	48	45.3	46.1	47.2
>12 years	21.6	22.6	25.8	22.7
Unknown	3	4.1	3.3	3.2
Prepregnancy BMI				
Underweight (BMI<19.8)	12.3	11	10.6	11.7
Normal weight	39.7	33.9	36.7	38.3
Overweight	12.4	9.9	10.9	11.8
Obese (BMI>29)	25.2	18.8	19.8	23.2
Unknown	10.3	26.4	22	15
Pregravid Smoking				
Smoked before pregnancy	35.6	29.9	18	30.9
Unknown	10.8	23.5	43.3	19.7
Medicaid	72.6	36.6	50.7	63.2
Unknown	0.5	20.7	2.6	3.5
AFDC/TANF	14.9	8	9.4	12.8
Unknown	1.4	20	2.4	4
Food Stamps	26.4	13.9	14.2	22.1
Unknown	2.4	21.4	3.7	5.1

Table 4, Continued. Characteristics of WIC Enrollees, By Completeness of Records				
Standardized Poverty Distribution				
0 - 50	35.8	36.2	33.1	35.2
51 - 100	23.6	22	21.6	22.9
101 - 130	11.4	10.1	11.6	11.3
131 - 150	5.8	5.2	6.4	5.9
151 - 185	5.8	5.8	7.7	6.2
186 - 200	1.1	0.8	1.3	1.1
Over 200	2.1	1.5	2.1	2
Unknown or adjunctive eligibility	14.4	18.4	16.2	15.3
States (Years), Distribution Across Columns				
Florida (2002-04)	63.58	15.98	20.44	
Georgia (1999-2004)	30.87	19.77	49.36	
Indiana (1995-1999, 2001-2004)	65.45	11.44	23.11	
Michigan (1996-2004)	73.98	7.82	18.21	
Missouri (1995-2004)	71.39	7.91	20.71	
North Carolina (1996-2003)	71.94	11.78	16.28	
New Jersey (2000-2004)	58.81	22.43	18.75	
Ohio (1999-2004)	73.53	10.35	16.12	
Virgina (2004)	67.26	9.72	23.03	
N	2,060,469	393,573	715,396	3,169,438

Table 5. Composition of Final Sample, by State					
States	**# Obs.**	**# Dropped**	**# Final Sample**	**# Final Sample (Singletons)**	**% of Final Sample (Singletons)**
FL	876,583	587,697	288,886	284,177	10.7
GA	370,516	76,284	294,232	292,648	11.0
IL	772,175	772,175	0	0	0.0
IN	388,227	71,714	316,513	311,564	11.7
MI	588,177	125,199	462,978	455,250	17.2
MO	432,022	42,315	389,707	383,581	14.5
NC	437,228	54,797	382,431	371,382	14.0
NJ	284,602	126,628	157,974	155,583	5.9
OH	421,649	55,948	365,701	362,255	13.6
VA	44,105	5,974	38,131	37,463	1.4
TOTAL	4,615,284	1,918,731	2,696,553	2,653,903	

Table 6. Final Sample, by Year and State: Singleton Births

	FL	GA	IN	MI	MO	NC	NJ	OH	VA	Total	% of Final Sample
1995	0	0	37,051	0	37,282	0	0	0	0	74,333	2.8
1996	0	0	34,829	50,676	38,294	43,401	0	0	0	167,200	6.3
1997	0	0	34,975	49,092	37,756	44,404	0	0	0	166,227	6.3
1998	0	0	38,286	50,916	39,631	46,387	0	0	0	175,220	6.6
1999	0	44,745	38,150	47,865	38,411	45,264	0	58,268	0	272,703	10.3
2000	0	49,460	0	51,925	38,283	48,225	28,781	60,809	0	277,483	10.5
2001	0	51,502	27,229	50,808	38,532	47,890	29,448	60,293	0	305,702	11.5
2002	97,359	50,514	28,717	49,566	35,549	47,831	30,037	60,151	0	399,724	15.1
2003	99,523	51,956	33,982	50,979	39,341	47,980	33,067	61,200	0	418,028	15.8
2004	87,295	44,471	38,345	53,423	40,502	0	34,250	61,534	37,463	397,283	15.0
Total	284,177	292,648	311,564	455,250	383,581	371,382	155,583	362,255	37,463	**2,653,903**	

Table 7. Selected Characteristics, Prenatal WIC Participants						
.	2000		2002		2004	
	PNSS+	USDA	PNSS+	USDA	PNSS+	USDA
Trimester of WIC Enrollment						
First Trimester	37.3	47.7	35.1	48.4	35.9	50.7
Second Trimester	39.7	39.0	41.5	39.8	41.8	38.4
Third Trimester	22.8	11.7	23.0	10.6	21.9	9.7
Trimester not reported	0.2	1.6	0.4	1.3	0.4	1.2
Race/Ethnicity						
Non-Hispanic White	53.9	40.0	49.0	39.3	49.1	38.4
Non-Hispanic Black	31.0	20.6	29.1	18.8	27.7	18.7
Native American	0.6	1.3	0.5	1.3	0.3	1.5
Asian	1.2	3.1	1.2	3.4	1.4	3.2
Hispanic	12.1	34.3	19.1	36.4	19.4	37.3
Other	1.2	0.7	1.1	0.8	2.1	0.9
Mother's Age						
Under 15 years	0.6	0.2	0.5	0.5	0.5	0.5
15-17	8.6	3.8	7.7	7.7	7.1	7.3
18-34	85.8	85.2	85.8	84.8	86.0	84.9
35 or older	5.1	10.7	6.0	6.5	6.3	6.7
Unknown	0.0	0.1	0.0	0.4	0.0	0.6
Standardized Poverty Level						
0-50	38.7	24.3	36.3	25.3	37.1	27.4
51-100	24.2	27.3	25.7	26.0	27.5	27.5
101-130	12.5	14.0	12.1	13.7	11.9	13.5
131-150	6.5	7.7	5.9	7.1	6.3	6.6
151-185	6.7	10.4	6.3	9.7	7.2	9.0
186-200	1.6	0.5	1.1	0.5	1.2	0.6
Over 200	2.5	1.0	2.4	1.2	2.3	1.1
Unknown or Adjunctively Eligible	7.4	14.9	10.1	16.5	6.5	14.4
N	204,176	898,210	303,078	878,619	301,628	940,514

+Nine PNSS States: FL (2002,2004), GA, IN (2002,2004), MI, NC (2000,2002), NJ, OH, VA (2004). For comparability with USDA, includes multiple gestations.

Table 8. Selected Infant Birth Outcomes						
	2000		2002		2004	
	PNSS+	USDA	PNSS+	USDA	PNSS+	USDA
FL						
Mean Birthweight (g)	na	3,258.3	3,247.4	3,236.5	3,240.3	3,223.6
LBW (%)	na	8.2	8.2	9.0	8.3	9.2
Maternal Weight Gain (lbs)	na	30.8	31.1	31.5	31.4	31.6
GA						
Mean Birthweight (g)	3,255.6	3,236.6	3,248.2	3,216.1	3,223.7	3,202.4
LBW (%)	8.1	8.8	7.9	9.5	8.1	9.7
Maternal Weight Gain (lbs)	30.2	na	30.4	na	30.3	na
IN						
Mean Birthweight (g)	na	3,278.7	3,267.5	3,257.0	3,245.2	3,247.3
LBW (%)	na	7.9	7.3	8.3	8.4	8.4
Maternal Weight Gain (lbs)	na	31.2	33.5	33.8	33.4	33.9
MI						
Mean Birthweight (g)	3,307.3	na	3,292.6	na	3,280.7	na
LBW (%)	7.1	na	7.2	na	7.7	na
Maternal Weight Gain (lbs)	27.0	31.6	27.8	na	29.0	na
MO						
Mean Birthweight (g)	3,265.4	3,271.7	3,249.9	3,243.8	3,242.5	3,232.1
LBW (%)	8.2	8.3	8.2	8.7	8.5	9.1
Maternal Weight Gain (lbs)	32.4	32.5	32.0	32.5	32.2	29.5
NC						
Mean Birthweight (g)	3,224.0	3,254.7	3,207.8	3,228.7	na	3,219.6
LBW (%)	9.9	8.9	10.1	9.4	na	9.7
Maternal Weight Gain (lbs)	29.9	28.1	29.6	28.1	na	28.1
NJ						
Mean Birthweight (g)	3,290.2	3,261.5	3,288.6	3,252.5	3,260.5	3,247.6
LBW (%)	7.3	8.4	7.0	8.7	7.6	8.5
Maternal Weight Gain (lbs)	31.2	30.8	30.3	30.5	30.4	30.3
OH						
Mean Birthweight (g)	3,248.6	3,240.0	3,233.8	3,216.1	3,225.5	3,202.5
LBW (%)	8.8	9.1	8.7	9.6	8.9	9.7
Maternal Weight Gain (lbs)	32.1	32.7	32.1	33.0	32.1	32.9
VA						
Mean Birthweight (g)	na	na	na	na	3,214.6	3,196.5
LBW (%)	na	na	na	na	9.6	15.2
Maternal Weight Gain (lbs)	na	na	na	na	30.8	na

+Includes multiple gestations for comparability with USDA.

Table 9. Characteristics of WIC Enrollees, By Timing of WIC Enrollment: Singleton Births	First Trimester (WIC1)	Second Trimester (WIC2)	Third Trimester (WIC3)	Postpartum WIC (WIC4)	Total	Prenatal-Postpartum*
Race/Ethnicity						
Non-Hispanic White	63.3	49.8	50.0	49.2	53.4	5.7
Non-Hispanic Black	23.4	31.4	32.5	32.9	29.8	-4.3
Native American	0.6	0.6	0.5	0.4	0.5	0.2
Asian	0.9	1.3	1.4	1.7	1.3	-0.6
Hispanic	10.9	15.9	14.5	14.6	13.9	-0.9
Other	0.9	1.1	1.1	1.2	1.1	-0.2
Mother's Age						
Under 20	26.1	25.1	22.5	18.7	23.3	6.2
20-29	58.7	58.2	60.6	60.9	59.4	-2.0
30 and over	15.2	16.6	17.0	20.4	17.3	-4.2
Unknown	0.0	0.0	0.0	0.0	0.0	0.0
Marital Status						
Married	34.1	30.2	31.6	37.2	33.3	-5.2
Unknown	4.3	5.6	5.4	5.0	5.0	0.0
Parity						
0	46.1	45.4	45.0	39.9	44.1	5.7
1-3 births	41.9	45.2	46.7	25.8	39.5	18.5
4+ births	2.9	3.7	3.8	2.5	3.2	0.9
Unknown	9.0	5.6	4.6	31.8	13.2	-25.1
Education Level (Women >=20 years)						
<12 years	27.5	28.1	26.2	24.6	26.6	2.8
12 years	48.6	47.5	47.9	46.4	47.6	1.6
>12 years	20.9	21.3	22.9	25.7	22.7	-4.2
Unknown	3.0	3.1	3.0	3.3	3.1	-0.3
Pre-Pregnancy BMI						
Underweight (BMI<19.8)	11.8	12.6	13.0	10.7	12.0	1.7
Normal weight	36.7	41.0	43.4	37.0	39.2	2.9
Overweight	12.1	12.6	12.6	11.0	12.0	1.4
Obese (BMI>29)	27.3	24.4	22.7	19.8	23.8	5.3
Unknown	12.1	9.3	8.2	21.5	13.1	-11.4
Pregravid Smoking						
Smoked before pregnancy	39.6	33.2	33.1	18.1	31.1	17.5
Unknown	11.5	10.3	9.8	43.2	19.1	-32.5
Medicaid	77.7	71.8	65.2	51.0	67.0	21.5
Unknown	0.5	0.5	0.6	2.6	1.1	-2.1
AFDC/TANF	14.2	15.4	15.0	9.3	13.4	5.5
Unknown	1.5	1.4	1.5	2.5	1.7	-1.0
Food Stamps	26.9	26.4	24.6	14.0	23.0	12.2
Unknown	2.7	2.4	2.3	3.8	2.8	-1.3

Table 9, Continued. Characteristics of WIC Enrollees, By Timing of WIC Enrollment: Singleton Births						
Standardized Poverty Level						
0-50	34.2	36.6	36.8	33.0	35.0	2.8
51-100	24.7	23.5	21.6	21.8	23.1	1.7
101-130	12.0	11.1	10.9	11.7	11.5	-0.3
131-150	6.0	5.6	5.9	6.5	6.0	-0.7
151-185	5.7	5.5	6.4	7.7	6.3	-1.9
186-200	1.1	1.1	1.4	1.3	1.2	-0.1
Over 200	2.0	2.0	2.5	2.0	2.1	0.1
Unknown or Adjunctively Eligible	14.3	14.6	14.5	16.1	14.9	-1.6
States (Years), Across Columns						
Florida (2002-04)	21.7	34.7	19.3	24.3		
Georgia (1999-2004)	19.9	12.6	5.4	62.2		
Indiana (1995-1999, 2001-2004)	29.6	29.0	15.3	26.1		
Michigan (1996-2004)	27.5	33.7	19.7	19.1		
Missouri (1995-2004)	36.8	26.8	13.6	22.9		
North Carolina (1996-2003)	31.7	32.8	17.0	18.5		
New Jersey (2000-2004)	19.0	37.2	19.1	24.7		
Ohio (1999-2004)	28.9	32.3	20.7	18.1		
Virgina (2004)	24.8	32.6	16.5	26.1		
N	739,811	790,391	434,125	689,576	2,653,903	

*Unadjusted differences

Table 10. Characteristics of WIC Participants by State: Singleton Births

	FL			GA			IN			MI		
	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.
Race/Ethnicity												
Non-Hispanic White	32.7	36.6	-3.9	40.8	36.2	4.6	71.1	68.0	3.1	61.2	56.0	5.2
Non-Hispanic Black	30.3	27.8	2.5	45.8	42.8	3.0	18.1	20.4	-2.3	28.4	35.6	-7.2
Native American	0.2	0.3	-0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.5	0.4	0.1
Asian	1.2	1.9	-0.7	1.0	1.8	-0.8	0.6	0.8	-0.2	1.1	1.6	-0.5
Hispanic	34.1	32.2	1.9	11.9	18.3	-6.4	9.4	9.6	-0.2	8.7	6.5	2.2
Other	1.4	1.3	0.1	0.4	0.8	-0.4	0.7	0.9	-0.2	0.0	0.0	0.0
Mother's Age												
Under 20	20.9	13.7	7.2	17.8	25.3	-7.5	28.9	18.8	10.1	25.2	16.5	8.7
20-29	56.4	60.0	-3.6	65.6	56.3	9.3	58.3	64.0	-5.7	59.0	61.6	-2.6
30 and over	22.7	26.3	-3.6	16.6	18.4	-1.8	12.8	17.3	-4.5	15.8	21.9	-6.1
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Married	33.4	42.3	-8.9	35.7	33.4	2.3	30.7	36.3	-5.6	29.4	37.2	-7.8
Unknown	2.0	1.8	0.2	0.3	0.3	0.0	8.4	13.1	-4.7	7.3	6.8	0.5
Parity												
0	43.9	39.3	4.6	0.0	0.0	0.0	46.0	45.8	0.2	69.6	0.0	69.6
1-3 births	52.0	56.0	-4.0	0.0	0.0	0.0	50.3	12.0	38.3	28.0	0.0	28.0
4+ births	4.1	4.6	-0.5	0.0	0.0	0.0	3.3	1.0	2.3	2.4	0.0	2.4
Unknown	0.0	0.0	0.0	100.0	100.0	0.0	0.4	41.2	-40.8	0.0	100.0	-100.0
Education Level (Women >=20 years)												
<12 years	29.3	24.8	4.5	36.7	29.6	7.1	23.5	21.3	2.2	31.8	27.2	4.6
12 years	50.8	49.7	1.1	44.8	43.3	1.5	39.7	41.2	-1.5	45.8	45.5	0.3
>12 years	18.9	24.4	-5.5	17.0	23.7	-6.7	17.2	21.9	-4.7	22.4	27.3	-4.9
Unknown	1.0	1.0	0.0	1.5	3.4	-1.9	19.7	15.5	4.2	0.0	0.0	0.0

Table 10, Continued. Characteristics of WIC Participants by State: Singleton Births*

	FL			GA			IN			MI		
	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.
Pre-Pregnancy BMI												
Underweight (BMI<19.8)	11.8	11.3	0.5	9.2	12.4	-3.2	14.7	9.1	5.6	12.4	9.4	3.0
Normal weight	45.7	43.5	2.2	33.9	45.1	-11.2	41.7	27.7	14.0	42.2	35.6	6.6
Overweight	14.4	12.5	1.9	13.3	13.9	-0.6	12.3	7.3	5.0	13.1	10.8	2.3
Obese (BMI>29)	25.1	20.5	4.6	28.7	24.2	4.5	25.3	13.0	12.3	26.9	20.2	6.7
Unknown	3.0	12.2	-9.2	15.0	4.4	10.6	6.0	42.9	-36.9	5.4	24.0	-18.6
Smoked before pregnancy	15.7	0.0	15.7	0.0	0.0	0.0	46.9	32.4	14.5	38.9	23.7	15.2
Unknown	2.0	100.0	-98.0	100.0	100.0	0.0	0.3	2.3	-2.0	18.1	28.6	-10.5
Medicaid	68.0	46.4	21.6	74.0	60.0	14.0	77.9	46.7	31.2	72.1	49.3	22.8
Unknown	3.1	7.6	-4.5	3.0	3.0	0.0	0.0	7.2	-7.2	0.2	0.0	0.2
AFDC/TANF	7.8	5.2	2.6	2.6	1.4	1.2	8.7	6.4	2.3	23.2	20.3	2.9
Unknown	3.8	8.2	-4.4	3.0	3.0	0.0	7.2	7.1	0.1	0.2	0.0	0.2
Foodstamps	24.4	16.2	8.2	3.7	1.7	2.0	23.8	12.7	11.1	33.5	26.6	6.9
Unknown	3.8	8.1	-4.3	3.0	3.0	0.0	7.2	7.2	0.0	0.2	0.0	0.2
Standardized Poverty Level												
0-50	37.0	34.6	2.4	42.0	37.7	4.3	6.9	6.0	0.9	39.4	38.9	0.5
51-100	35.0	27.8	7.2	33.7	31.1	2.6	9.8	7.5	2.3	23.8	19.8	4.0
101-130	12.7	11.9	0.8	13.2	15.1	-1.9	6.6	6.3	0.3	12.1	11.5	0.6
131-150	5.4	6.2	-0.8	5.4	7.0	-1.6	3.6	4.4	-0.8	6.5	7.3	-0.8
151-185	5.1	7.8	-2.7	5.3	8.2	-2.9	3.1	3.8	-0.7	8.2	12.3	-4.1
186-200	0.4	0.4	0.0	0.2	0.3	-0.1	0.1	0.0	0.1	2.2	4.2	-2.0
Over 200	0.6	0.6	0.0	0.3	0.5	-0.2	0.4	0.1	0.3	3.7	5.6	-1.9
Unknown or Adjunctively Eligible	3.8	10.7	-6.9	0.0	0.2	-0.2	69.5	71.7	-2.2	4.2	0.3	3.9
N	215,017	69,160		110,732	181,916		230,278	81,286		368,106	87,144	

Table 10, Continued. Characteristics of WIC Participants by State: Singleton Births*

	MO			NC			NJ			OH		
	Prenatal WIC	**Postpartum WIC**	**Diff.**	**Prenatal WIC**	**Postpartum WIC**	**Diff.**	**Prenatal WIC**	**Postpartum WIC**	**Diff.**	**Prenatal WIC**	**Postpartum WIC**	**Diff.**
Race/Ethnicity												
Non-Hispanic White	70.4	64.0	6.4	44.3	47.4	-3.1	18.1	17.9	0.2	67.1	67.3	-0.2
Non-Hispanic Black	22.1	27.9	-5.8	38.1	35.4	2.7	26.4	35.0	-8.6	26.3	25.8	0.5
Native American	0.2	0.3	-0.1	2.3	2.4	-0.1	0.2	0.3	-0.1	0.1	0.1	0.0
Asian	0.8	1.2	-0.4	1.4	1.9	-0.5	3.0	3.8	-0.8	0.7	1.0	-0.3
Hispanic	3.8	3.7	0.1	13.9	12.9	1.0	48.8	38.5	10.3	4.6	4.4	0.2
Other	2.5	2.9	-0.4	0.0	0.0	0.0	3.5	4.5	-1.0	1.2	1.4	-0.2
Mother's Age												
Under 20	28.7	16.7	12.0	24.4	16.2	8.2	18.6	14.6	4.0	26.5	17.2	9.3
20-29	57.6	63.7	-6.1	60.3	64.2	-3.9	56.7	57.5	-0.8	59.3	64.0	-4.7
30 and over	13.6	19.5	-5.9	15.3	19.6	-4.3	24.7	27.9	-3.2	14.2	18.8	-4.6
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Married	32.6	39.6	-7.0	43.2	52.8	-9.6	25.0	25.4	-0.4	27.5	36.6	-9.1
Unknown	0.1	0.1	0.0	0.1	0.0	0.1	17.2	17.2	0.0	0.0	0.0	0.0
Parity												
0	43.3	35.6	7.7	44.6	35.1	9.5	46.5	99.4	-52.9	37.7	31.1	6.6
1-3 births	52.7	58.0	-5.3	52.1	60.3	-8.2	49.6	0.5	49.1	51.4	56.0	-4.6
4+ births	4.0	6.3	-2.3	3.4	4.6	-1.2	3.9	0.0	3.9	4.4	7.1	-2.7
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	5.8	0.7
Education Level (Women >=20 years)												
<12 years	27.1	22.8	4.3	28.2	23.8	4.4	27.0	23.4	3.6	21.1	19.1	2.0
12 years	49.5	46.2	3.3	44.1	42.1	2.0	48.8	51.3	-2.5	55.7	54.3	1.4
>12 years	23.4	31.0	-7.6	27.5	33.8	-6.3	21.8	22.8	-1.0	20.7	23.2	-2.5
Unknown	0.0	0.0	0.0	0.2	0.3	-0.1	2.5	2.5	0.0	2.4	3.5	-1.1

Table 10, Continued. Characteristics of WIC Participants by State: Singleton Births*

	MO			NC			NJ			OH		
	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.	Prenatal WIC	Postpartum WIC	Diff.
Pre-Pregnancy BMI												
Underweight (BMI<19.8)	15.0	14.5	0.5	9.4	7.4	2.0	10.3	1.4	8.9	13.5	13.7	-0.2
Normal weight	44.0	46.9	-2.9	27.2	21.3	5.9	46.9	5.4	41.5	40.1	44.5	-4.4
Overweight	12.9	13.0	-0.1	8.5	7.0	1.5	14.5	1.9	12.6	12.4	13.2	-0.8
Obese (BMI>29)	27.4	24.4	3.0	18.4	14.2	4.2	22.3	3.2	19.1	26.9	25.1	1.8
Unknown	0.7	1.2	-0.5	36.5	50.0	-13.5	6.0	88.1	-82.1	7.1	3.5	3.6
Smoked before pregnancy	44.2	33.4	10.8	39.3	29.7	9.6	11.4	6.2	5.2	47.9	39.1	8.8
Unknown	0.1	0.1	0.0	0.3	1.2	-0.9	21.9	22.5	-0.6	0.1	1.0	-0.9
Medicaid	73.2	45.8	27.4	79.9	57.7	22.2	58.9	42.4	16.5	69.3	43.2	26.1
Unknown	0.0	1.5	-1.5	0.0	0.0	0.0	0.0	0.3	-0.3	0.0	0.0	0.0
AFDC/TANF	21.5	18.8	2.7	10.1	7.7	2.4	8.3	8.7	-0.4	20.6	14.1	6.5
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.0	0.0	0.0
Foodstamps	33.0	22.1	10.9	20.1	13.5	6.6	14.4	12.6	1.8	33.7	21.9	11.8
Unknown	6.9	10.4	-3.5	0.0	0.0	0.0	0.0	0.3	-0.3	0.0	0.0	0.0
Standardized Poverty Level												
0-50	35.1	39.3	-4.2	41.8	33.5	8.3	22.1	28.1	-6.0	49.4	42.5	6.9
51-100	29.2	23.7	5.5	17.6	11.6	6.0	33.8	30.3	3.5	18.3	16.0	2.3
101-130	13.5	14.0	-0.5	9.9	7.4	2.5	14.6	14.0	0.6	10.7	10.8	-0.1
131-150	6.8	8.1	-1.3	5.2	4.5	0.7	6.4	6.7	-0.3	6.4	7.3	-0.9
151-185	5.7	7.6	-1.9	2.4	2.3	0.1	5.9	7.3	-1.4	8.6	12.1	-3.5
186-200	0.4	0.4	0.0	1.1	1.0	0.1	0.6	0.3	0.3	2.7	4.8	-2.1
Over 200	1.0	1.1	-0.1	3.1	3.0	0.1	1.0	0.7	0.3	3.9	6.6	-2.7
Unknown or Adjunctively Eligible	8.4	5.8	2.6	18.9	36.7	-17.8	15.7	12.6	3.1	0.0	0.0	0.0
N	295,776	87,805		302,766	68,616		117,209	38,374		296,771	65,484	

Table 10, Continued . Characteristics of WIC Participants by State: Singleton Births*

VA			
	Prenatal WIC	**Postpartum WIC**	**Diff.**
Race/Ethnicity			
Non-Hispanic White	41.4	42.3	-0.9
Non-Hispanic Black	38.5	35.7	2.8
Native American	0.3	0.6	-0.3
Asian	2.3	3.5	-1.2
Hispanic	17.6	17.9	-0.3
Other	0.0	0.0	0.0
Mother's Age			
Under 20	22.3	14.7	7.6
20-29	60.0	63.7	-3.7
30 and over	17.8	21.6	-3.8
Unknown	0.0	0.0	0.0
Married	0.0	0.0	0.0
Unknown	100.0	100.0	0.0
Parity			
0	34.9	0.0	34.9
1-3 births	55.3	0.0	55.3
4+ births	9.9	0.0	9.9
Unknown	0.0	100.0	-100.0
Education Level (Women >=20 years)			
<12 years	9.1	6.7	2.4
12 years	77.7	80.0	-2.3
>12 years	8.4	8.4	0.0
Unknown	4.8	4.9	-0.1

Table 10, Continued. Characteristics of WIC Participants by State: Singleton Births*

	VA			
	Prenatal WIC	Postpartum WIC	Diff.	
Pre-Pregnancy BMI				
Underweight (BMI<19.8)	10.7	6.6	4.1	
Normal weight	39.8	25.8	14.0	
Overweight	14.3	9.0	5.3	
Obese (BMI>29)	28.9	15.1	13.8	
Unknown	6.1	43.4	-37.3	
Smoked before pregnancy	33.1	0.0	33.1	
Unknown	0.0	100.0	-100.0	
Medicaid	68.2	52.7	15.5	
Unknown	0.0	0.0	0.0	
AFDC/TANF	4.6	3.8	0.8	
Unknown	0.0	0.0	0.0	
Foodstamps	15.8	11.8	4.0	
Unknown	0.0	0.0	0.0	
Standardized Poverty Level				
0-50	46.3	0.0	46.3	
51-100	21.1	0.0	21.1	
101-130	12.6	0.0	12.6	
131-150	7.5	0.0	7.5	
151-185	9.8	0.0	9.8	
186-200	0.8	0.0	0.8	
Over 200	1.7	0.0	1.7	
Unknown or Adjunctively Eligible	0.2	100.0	-99.8	
N	27,672	9,791		2,653,903

Table 11. Smoking Among Unmarried Women 18-44 Years Old With 12 or Fewer Years of Education*

	PNSS		Natality	
	%	**N**	**%**	**N**
1995	45.2	21,292	41.0	22,554
1996	42.1	47,366	34.7	59,470
1997	40.9	48,235	34.4	60,690
1998	40.3	52,426	33.5	63,914
1999	40.6	87,799	32.0	112,180
2000	36.0	95,211	28.8	121,589
2001	35.4	107,662	29.9	140,570

*GA, 1999-2001; IN, 1995-1999, 2001-2001; MI, 1996-2001; MO, 1995-2001; NC, 1996-2001; NJ, 2000-2001; OH, 1999-2001; FL, VA not included

Table 12. Adjusted Differences in Birth Outcomes by the Timing of WIC Enrollment

	BW		LBW		VLBW		Preterm	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Timing of WIC								
During pregnancy	58.6**	62.2**	-0.025**	-0.027**	-0.008**	-0.009**	-0.025**	-0.028**
First trimester	55.0**	59.3**	-0.021**	-0.022**	-0.004**	-0.005**	-0.010**	-0.013**
Second trimester	50.5**	54.4**	-0.018**	-0.019**	-0.004**	-0.005**	-0.018**	-0.021**
Third trimester	79.0**	84.0**	-0.032**	-0.033**	-0.009**	-0.009**	-0.056**	-0.060**
Difference by trimesters								
1st-3rd	-24.0**	-24.7**	0.011**	0.011**	0.005**	0.004**	0.046**	0.047**
1st-2nd	4.5	4.9	-0.003**	-0.003*	0.000	0.000	0.008**	0.008**
Medicaid only	No	Yes	No	Yes	No	Yes	No	Yes
Mean dep var	3,269.2	3,250.7	0.077	0.08	0.01	0.011	0.115	0.118
Observations	2,476,727	1,661,401	2,476,727	1,661,401	2,476,727	1,661,401	1,972,111	1,341,349
R-squared	0.05	0.05						

+ p<0.10, * p<0.05, ** p<.01

Table 13. Adjusted Differences in Birth Outcomes by the Timing of WIC Enrollment & By Race/Ethnicity

	BW			LBW		
	White	Black	Hispanic	White	Black	Hispanic
Timing of WIC						
During pregnancy	50.7**	72.9**	58.9**	-0.022**	-0.035**	-0.020**
First trimester	48.1**	62.4**	64.1**	-0.019**	-0.027**	-0.017**
Second trimester	41.7**	64.5**	53.3**	-0.014**	-0.027**	-0.015**
Third trimester	70.3**	101.4**	62.9**	-0.027**	-0.046**	-0.024**
Difference by trimesters						
1st-3rd	-22.2**	-39.0**	1.2	0.008**	0.019**	0.007**
1st-2nd	6.4	-2.1	10.8**	-0.005**	0.000	-0.002*
Mean dep var	3,321.2	3,146.4	3,327.8	0.07	0.11	0.05
Observations	1,335,987	726,362	342,703	1,335,987	726,362	342,703
R-squared	0.04	0.03	0.03			

	VLBW			Preterm		
	White	Black	Hispanic	White	Black	Hispanic
Timing of WIC						
During pregnancy	-0.007**	-0.012**	-0.005**	-0.024**	-0.032**	-0.014**
First trimester	-0.004**	-0.006**	-0.003**	-0.011**	-0.010+	0.004
Second trimester	-0.004**	-0.008**	-0.003**	-0.017**	-0.022**	-0.009**
Third trimester	-0.007**	-0.015**	-0.006**	-0.051**	-0.071**	-0.044**
Difference by trimesters						
1st-3rd	0.003**	0.009**	0.003**	0.040**	0.061**	0.048**
1st-2nd	0.000*	0.002**	0.000	0.006**	0.012**	0.013**
Mean dep var	0.01	0.02	0.01	0.10	0.14	0.11
Observations	1,335,987	726,362	342,703	1,043,013	584,696	285,028

+ p<0.10, * p<0.05, ** p<.01

Table 14. Adjusted Differences in Measures of Fetal Growth by Race & Ethnicity

	All	White	Black	Hispanic
	BW given gestational age			
Timing of WIC				
During pregnancy	39.2**	30.5**	48.8**	55.9**
First trimester	46.7**	34.5**	59.3**	77.8**
Second trimester	34.9**	26.2**	44.8**	51.0**
Third trimester	33.3**	29.6**	41.3**	35.9**
Difference by trimesters				
1st-3rd	13.4**	4.9	18.0**	41.9**
1st-2nd	11.8**	8.3**	14.5**	26.8**
Mean dep var	3,262.4	3,311.1	3,141.2	3,327.5
Observations	1,918,330	1,026,400	559,048	274,962
	Small for Gestational Age (SGA)			
Timing of WIC				
During pregnancy	-0.016**	-0.012**	-0.023**	-0.024**
First trimester	-0.018**	-0.012**	-0.026**	-0.028**
Second trimester	-0.015**	-0.011**	-0.021**	-0.023**
Third trimester	-0.014**	-0.012**	-0.019**	-0.016**
Difference by trimesters				
1st-3rd	-0.004**	0.000	-0.007**	-0.012**
1st-2nd	-0.003*	-0.001	-0.005**	-0.005**
Mean dep var	0.148	0.138	0.187	0.112
Observations	1,697,097	933,033	467,876	242,874
	Term Low Birth Weight			
Timing of WIC				
During pregnancy	-0.007**	-0.005**	-0.011**	-0.008**
First trimester	-0.007**	-0.005**	-0.011**	-0.008**
Second trimester	-0.005**	-0.003**	-0.009**	-0.007**
Third trimester	-0.008**	-0.006**	-0.011**	-0.006**
Difference by trimesters				
1st-3rd	0.001	0.001*	0.000	-0.002*
1st-2nd	-0.002**	-0.002*	-0.002**	-0.001**
Mean dep var	0.034	0.031	0.046	0.022
Observations	1,698,534	921,402	480,017	245,310

+ p<0.10, * p<0.05, ** p<.01

Table 15: Adjusted Differences in Measures of Fetal Growth by Risk Factors

	Pre-pregnancy BMI < 19.8			*Pre-pregnancy smokers*			*Multiple gestations*		
	BW|gest	**SGA**	**FTLBW**	**BW|gest**	**SGA**	**FTLBW**	**BW|gest**	**SGA**	**FTLBW**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Timing of WIC									
During pregnancy	31.6**	-0.013**	-0.008**	41.8**	-0.018**	-0.009**	52.9**	-0.002	-0.025*
First trimester	35.9**	-0.014**	-0.008**	46.6**	-0.018**	-0.009**	73.4**	-0.035**	-0.031*
Second trimester	29.7**	-0.014**	-0.006**	37.1**	-0.017**	-0.006**	42.5**	-0.001	-0.018
Third trimester	28.0**	-0.009*	-0.010**	41.0**	-0.015**	-0.010**	42.1**	0.046**	-0.029*
Difference by trimesters									
1st-3rd	7.9*	-0.005**	0.002	5.6	-0.003	0.001	31.3**	-0.081**	-0.002
1st-2nd	6.2+	0.000	-0.002	9.5	-0.001	-0.003**	30.9**	-0.034**	-0.013
Mean dep var	3,105.0	0.216	0.057	3,202.6	0.185	0.045	2,349.1	0.346	0.304
Observations	239,683	214,285	207,395	615,558	606,561	547,135	31,394	29,916	12,994

+ p<0.10, * p<0.05, ** p<.01

Table 16. Adjusted Differences in Birth Outcomes by the Timing of WIC Enrollment: Early Care, First Births

	BW	LBW	VLBW	Preterm	BW|gest	SGA	FTLBW
Timing of WIC							
During pregnancy	61.7**	-0.031**	-0.012**	-0.033**	24.5**	-0.008**	-0.006**
First trimester	60.4**	-0.027**	-0.007**	-0.013**	31.1**	-0.010**	-0.007**
Second trimester	50.2**	-0.022**	-0.007**	-0.025**	17.9**	-0.007*	-0.004**
Third trimester	82.8**	-0.034**	-0.010**	-0.060**	24.2**	-0.008**	-0.007**
Difference by trimesters							
1st-3rd	-22.4*	0.007**	0.003**	0.047**	6.9*	-0.002	0.000
1st-2nd	10.2+	-0.005**	0.000	0.012**	13.2**	-0.003**	-0.003*
Mean dep var	3,251.5	0.081	0.013	0.109	3,226.9	0.166	0.037
Observations	734,739	734,739	734,739	514,412	508,047	501,864	454,709
R-squared	0.04				0.35		

+ p<0.10, * p<0.05, ** p<.01

Table 17. Adjusted Differences in Maternal Behaviors and Health

	Quit Smoking Last 3 Months of Pregnancy~							
	All Pregravid Smokers		**Whites**		**Blacks**		**Hispanics**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
First trimester	0.017**	0.014**	0.011**	0.008**	0.038**	0.041**	-0.014	0.005
Second trimester	0.017**	0.017**	0.013**	0.012**	0.031**	0.035**	0.001	0.013
1st-2nd	0.000	-0.003	-0.002	-0.004+	0.007	0.006	-0.015*	-0.008
With North Carolina	Yes	No	Yes	No	Yes	No	Yes	No
Mean dep var	0.44	0.428	0.398	0.398	0.566	0.552	0.733	0.639
Observations	516,329	397,447	397,633	322,749	94,391	61,136	14,940	8,387

	Quit Smoking Postpartum							
	All Pregravid Smokers		**Whites**		**Blacks**		**Hispanics**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
First trimester	0.008**	0.010**	0.003	0.004*	0.032**	0.036**	0.007	0.010
Second trimester	0.013**	0.013**	0.009**	0.008**	0.026**	0.029**	0.011	0.010
1st-2nd	-0.005*	-0.003	-0.006*	-0.004*	0.006	0.007**	-0.004	0.000
Adj for weeks from birth to WIC postpartum	Yes	No	Yes	No	Yes	No	Yes	No
Mean dep var	0.346	0.333	0.300	0.294	0.491	0.449	0.598	0.57
Observations	407,446	623,791	315,750	485,474	70,983	107,693	12,829	20,206

	Ever Breastfed							
	All		**Whites**		**Blacks**		**Hispanics**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
During pregnancy	0.025*	0.024**	0.023*	0.007	0.012	0.028**	0.029**	0.043**
First trimester	0.040**	0.037**	0.038**	0.021**	0.023*	0.036**	0.044**	0.054**
Second trimester	0.026**	0.027**	0.024*	0.009+	0.016	0.033**	0.030**	0.043**
Third trimester	-0.005	-0.003	-0.011	-0.023**	-0.011	0.009	0.006	0.020*
1st-3rd	0.045**	0.040**	0.049**	0.041**	0.033**	0.027**	0.038**	0.034**
1st-2nd	0.014**	0.010**	0.014**	0.012**	0.007*	0.003	0.014**	0.011**
Adj for weeks from birth to WIC	Yes	No	Yes	No	Yes	No	Yes	No
Mean dep var	0.481	0.498	0.463	0.485	0.383	0.400	0.723	0.735
Observations	1,866,984	2,527,382	964,905	1,347,116	564,747	752,776	279,738	354,396

	Pregnancy Weight Gain (lbs)			
	All		**Underweight**	
	(1)	(2)	(3)	(4)
During pregnancy	-0.505**	0.117	0.033	0.640**
1st trimester	-0.520**	-0.187	0.432*	0.695**
2nd trimester	-0.451*	0.283	-0.021	0.693**
3rd trimester	-0.571**	0.354+	-0.531**	0.466*
1st-3rd	0.051	-0.541**	0.963**	0.229
1st-2nd	-0.069	-0.470**	0.453**	0.002
Adj for gestation	Yes	No	No	Yes
Mean dep var	31.5	30.6	35.3	34.2
Observations	1,875,118	2,489,828	238,281	303,028
R-squared	0.10	0.08	0.08	0.06

+ p<0.10, * p<0.05, ** p<.01

~ FL, GA, IN, NJ dropped due to missing data

FL, GA dropped due to missing data.

Table 18. Adjusted Differences in Birth Outcomes by the Timing of WIC Enrollment in North Carolina, 1996-2003

	BW		**LBW**		**VLBW**		**Preterm**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Timing of WIC								
During pregnancy	81.5**	82.2**	-0.034**	-0.035**	-0.011**	-0.011**	-0.047**	-0.047**
First trimester	65.1**	66.2**	-0.027**	-0.027**	-0.006**	-0.006**	-0.035**	-0.035**
Second trimester	70.0**	70.4**	-0.028**	-0.028**	-0.008**	-0.008**	-0.042**	-0.041**
Third trimester	132.5**	133.0**	-0.060**	-0.060**	-0.024**	-0.025**	-0.080**	-0.080**
Difference by trimesters								
1st-3rd	-67.4**	-66.8**	0.033**	0.033**	0.018**	0.019**	0.045**	0.045**
1st-2nd	-4.9	-4.2	0.001	0.001	0.002**	0.002**	0.007**	0.006**
Includes lost to follow-up	Yes	No	Yes	No	Yes	No	Yes	No
Mean dep var	3,237.3	3,248.6	0.090	0.086	0.019	0.015	0.105	0.101

	BW|gest		**SGA**		**Term LBW**		**Smoked during Pregnancy**	
Timing of WIC								
During pregnancy	14.6**	15.1**	-0.003**	-0.003**	-0.005**	-0.005**	-0.007**	-0.008**
First trimester	25.7**	26.4**	-0.006**	-0.006**	-0.005**	-0.005**	-0.005**	-0.006**
Second trimester	11.0**	11.4**	-0.003*	-0.003*	-0.003**	-0.003**	-0.011**	-0.012**
Third trimester	1.8	1.9	0.000	0.000	-0.007**	-0.007**	-0.002	-0.003
Difference by trimesters								
1st-3rd	23.9**	24.5**	-0.006**	-0.006**	0.002	0.002	-0.003	-0.003
1st-2nd	14.7**	15.0**	-0.003*	-0.003*	-0.002*	-0.002*	0.006**	0.006**
Includes lost to follow-up	Yes	No	Yes	No	Yes	No	Yes	No
Mean dep var	3,237.4	3,248.8	0.132	0.130	0.032	0.031	0.207	0.205

+ p<0.10, * p<0.05, ** p<.01

Table 19. Selected Means for North Carolina, by Completeness of Records			
	WIC Prenatal		
	Complete Records	**Lost to Follow-up**	**WIC Postpartum**
Birth weight (g)	3,261.7	3,152.7	3,190.9
LBW	7.9	12.2	11.5
VLBW	1.3	4.6	2.7
Unknown	0.0	0.3	0.1
Gestation (weeks)	38.8	38.2	38.3
Preterm	9.1	13.6	14.5
Unknown	0.0	0.0	0.2
SGA	13.2	14.1	12.4
Unknown	0.0	0.3	0.3
FTLBW	2.8	3.0	2.8
Unknown	9.2	13.7	14.7
Smoked during pregnancy	20.4	22.5	20.4
Unknown	0.1	0.2	0.2
N	302,766	50,057	68,616

Table 20. Results from Propensity Score Methods			
Outcome	**Adjusted Difference**	**Mean Dep Var**	**N**
Birth weight (g)|gestation	45.7**	3,231.5	1,815,916
SGA	-0.019**	0.15	1,697,097
FTLBW	-0.008**	0.04	1,609,130
Quit smoking, last 3 months of	0.013**	0.43	349,810
Quit smoking postpartum#	0.009**	0.33	390,938
Ever breastfed	0.043**	0.47	2,352,482
Weight gain (lbs)	0.100**	31.1	1,751,617

+ p<0.10, * p<0.05, ** p<.01

Compares first-trimester to third-trimester enrollees.

Figure 1.a. All States: Distribution of Gestational Age, Singleton Births

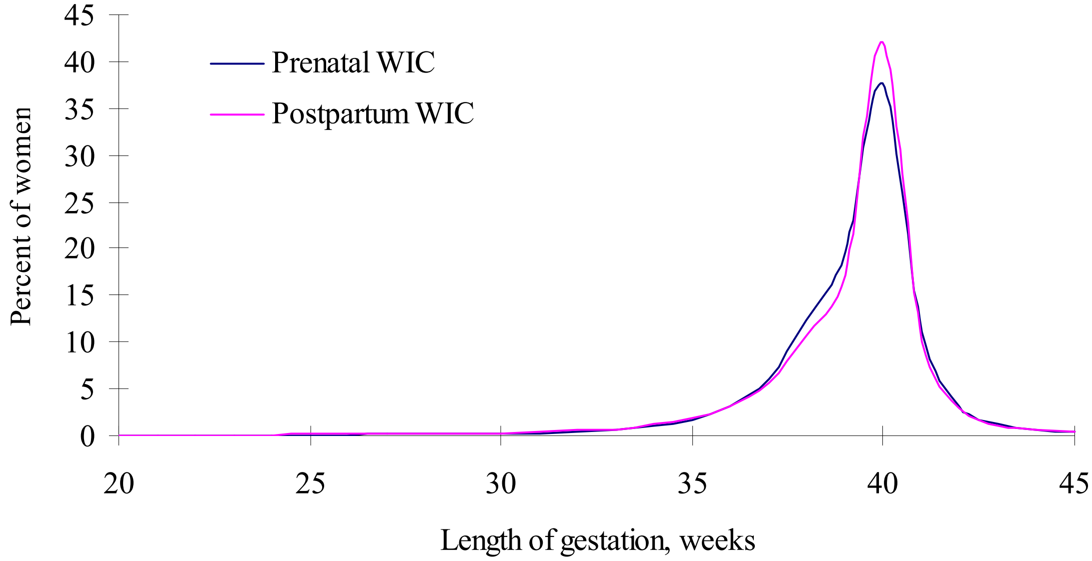


Figure 1.b. Michigan: Distribution of Gestational Age, Singleton Births

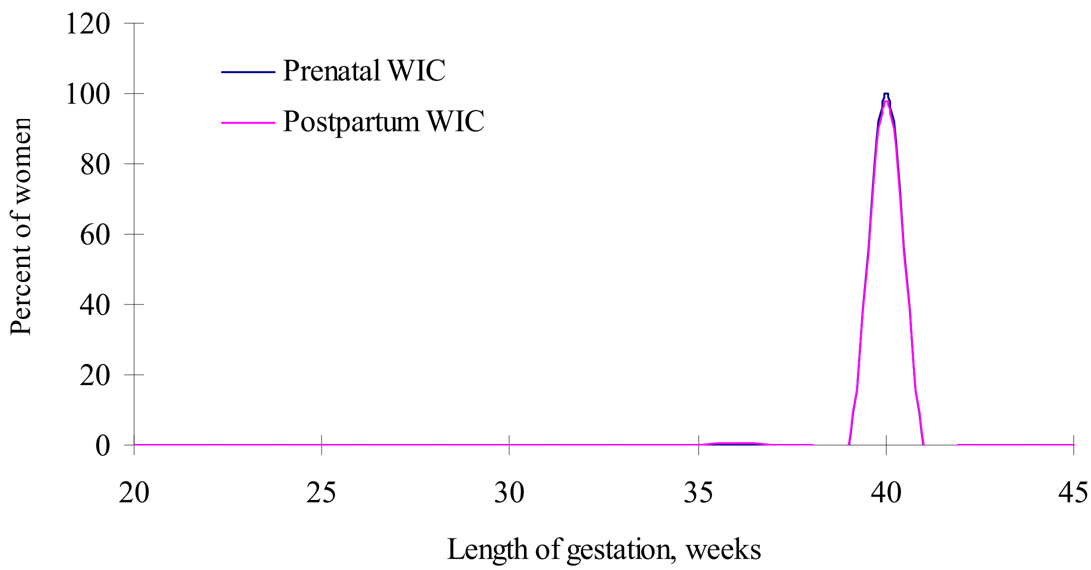


Figure 1.c. Virginia: Distribution of Gestational Age, Singleton Births

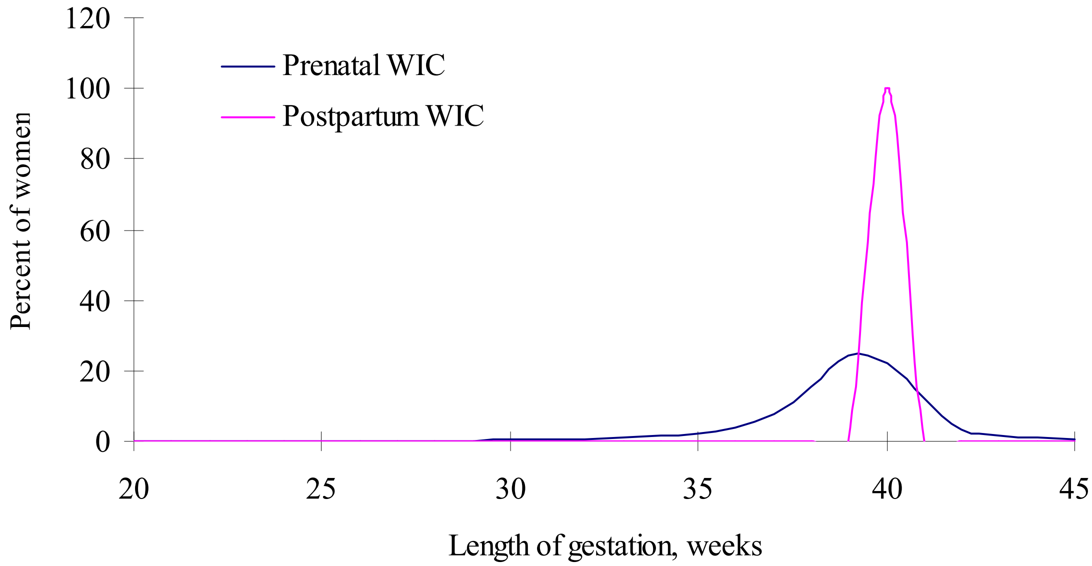


Figure 2. Low Birth Weight and Preterm Births by the Timing of WIC Enrollment

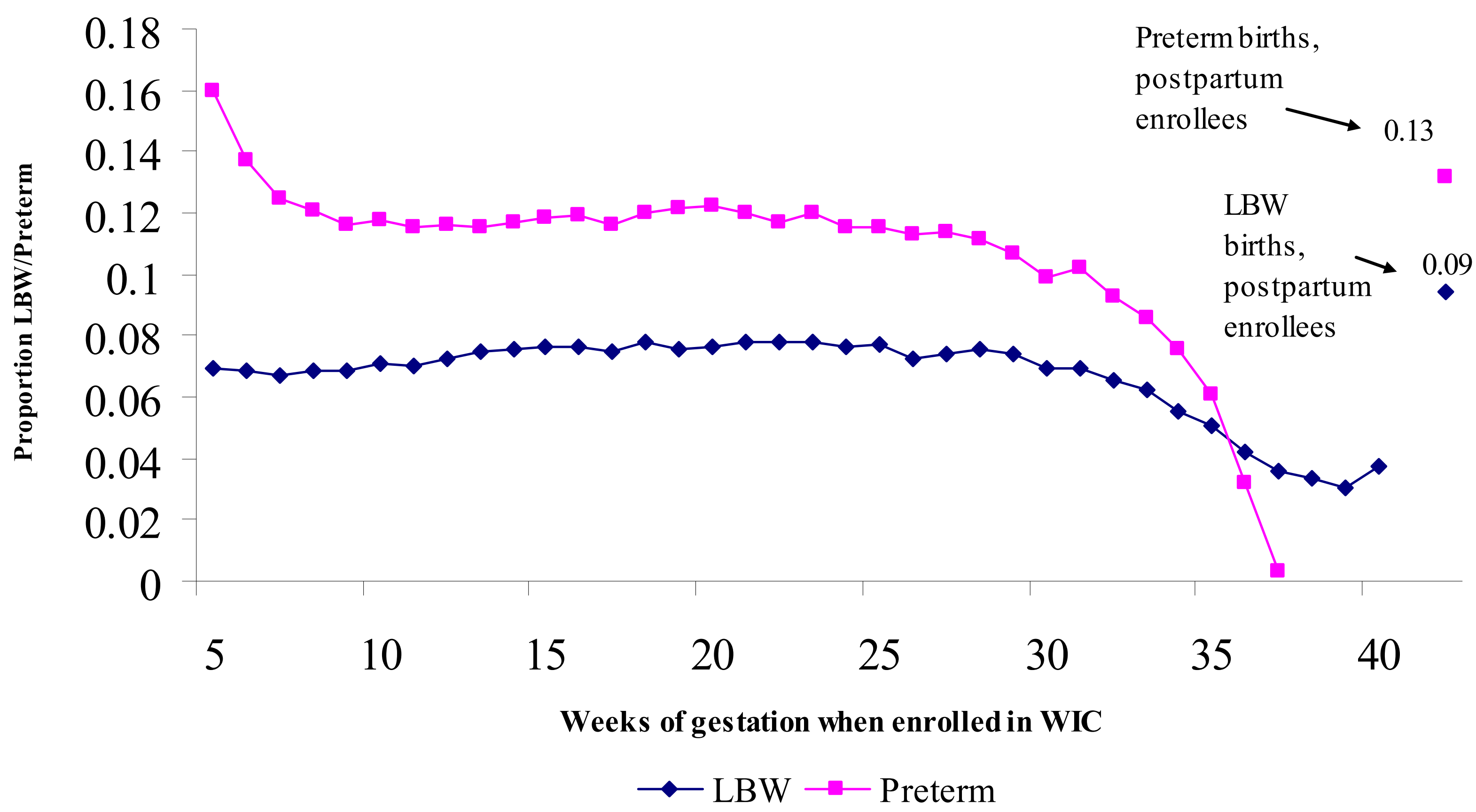
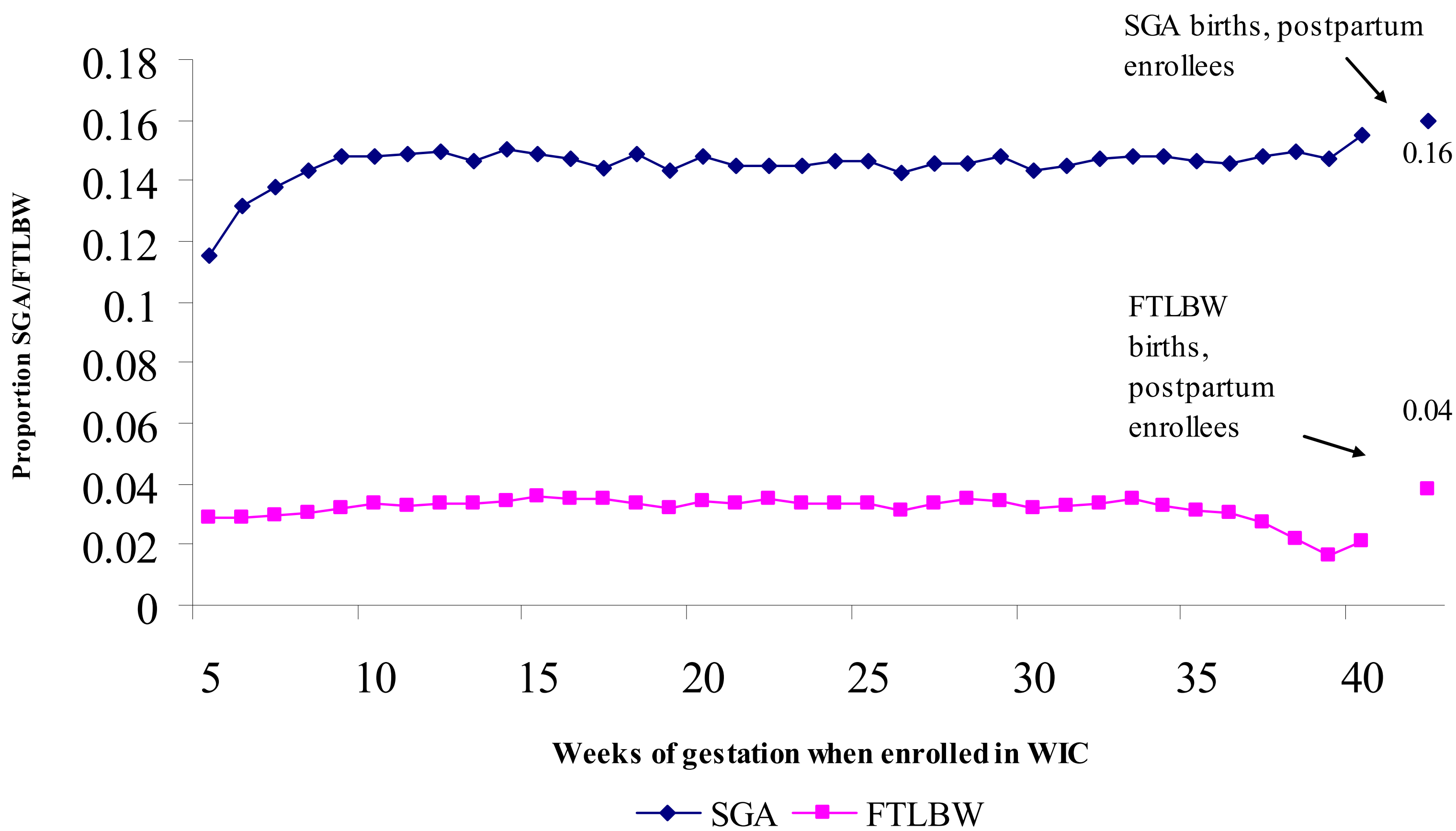


Figure 3. Small for Gestational Age and Full-Term Low Birth Weight by the Timing of WIC Enrollment



Chapter 2: Maternal Smoking and the Timing of WIC Enrollment

I. Introduction

The literature is unambiguous about the slew of complications faced by pregnant smokers. Health effects for the infant alone include increased risk of miscarriage, intrauterine growth retardation, and placental complications (Cnattingius, 2004; Surgeon General, 2001; Buescher, 1997; Floyd, et al., 1993; Kramer, 1986). In 2004, 12.5 percent of pregnant smokers with live births had low birth weight infants, compared with 7.8 percent for nonsmokers. The mortality rate for low birth weight infants is almost 26 times that of infants weighing more than 2,500 grams (National Center for Health Statistics, 2006).

NCHS figures show that in 2004, 10.2 percent of women who gave birth smoked during pregnancy, a 48 percent drop from 1989. While the decline is substantial, it deserves closer scrutiny. First, smoking on birth certificates is self-reported and likely understates true prevalence (Buescher, 1993). Simple yes/no questions about prenatal smoking are less likely to elicit accurate responses than more detailed inquiries on frequency and timing (Mullen, et al, 1991; Kharrazi, et al., 1999). Self-reports are even more problematic when smoking status is verified via biochemical markers; one study found a nonsmoking misclassification rate of 13.8 percent and a quitting misclassification rate of 26.2 percent (Boyd, et al., 1998).

The national averages also conceal significant variations in smoking by socio-economic status. For example, in 2004, pregnancy smoking among whites exceeded that of blacks and Hispanics by 5.4 and 11.2 percentage points. Twenty-four percent of high school dropouts (9-11 years of schooling) smoked; women with 0-8, 12, 13-15, and 16+ years of education smoked at rates of 5.5, 14.9, 8.4, and 1.5 percent (NCHS, 2006).

Among women on the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), the prevalence of smoking is even greater. North Carolina birth certificates in 1993-1994 indicate that 24.2 percent of prenatal WIC participants smoked, compared with 12.8 percent of non-participants (Buescher, 1997). Similar discrepancies were noted in 1988-1997 Pregnancy Risk Assessment Monitoring System (PRAMS) data from Maine: in 1997, 34.4 percent of respondents on WIC smoked; the rate was 12.6 percent for non-participants.[3]

Much of WIC research seems to largely link program relevance to its impact on birth outcomes, particularly preterm birth, despite the lack of clinical support for such a relationship. These numbers suggest that the disproportionate focus on a WIC-birth weight linkage may be obscuring a chance to more closely examine pregnancy smoking among WIC mothers - a large group of low-income women who smoke at rates that dwarf national averages. The literature has paid relatively little attention to the role of prenatal smoking on birth outcomes among WIC recipients. The studies that do demonstrate a link between WIC and fetal growth have not shown a corresponding association between WIC and prenatal smoking, an obvious pathway (Bitler and Currie, 2005; Lazariu-Bauer, et al., 2004).

In this paper, we look at the relationship between smoking and the timing of WIC participation by exploiting enrollment data from the Pregnancy Nutrition Surveillance System (PNSS). With information culled from prenatal and postpartum WIC interviews, we can compare smoking among women who enroll during the first and second trimesters to those who sign up later in pregnancy. Women are asked about smoking at

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[3] http://www.cdc.gov/MMWR/preview/mmwrhtml/mm4820a3.htm

pre-pregnancy, as of prenatal WIC registration, the last three months of pregnancy, and postpartum. Changes in smoking at the first two points cannot be attributed to WIC; any association may therefore serve as a marker for selection bias, particularly among women of zero parity.[4] Smoking cessation during the last three months of pregnancy is of particular interest because quitting during this period has been found to prevent fetal growth retardation (Ohmi, et al., 2005; Bernstein, et al., 2005; Lieberman, et al. 1994). Quitting postpartum still benefits both mother and infant, lowering the risk of respiratory infections and Sudden Infant Death Syndrome (SIDS) for the latter (Floyd, et al., 1993). Most women who manage to quit during pregnancy relapse postpartum (Fang, et al., 2004).

Overall, we find that, compared with third-trimester enrollees, first-trimester participants are more likely to report smoking pre-pregnancy and at WIC enrollment. Among pregravid smokers, both first and second-trimester WIC are associated with a 3 percent decline in smoking during the last three months of pregnancy and a 2 percent drop in postpartum smoking. Except for black women, however, the first-trimester impact disappears among women of zero parity. Effects are large and significant for women with previous live births, who may have received anti-smoking advice from earlier pregnancies or are more willing to adjust their behavior based on prior adverse birth outcomes.

[4] We include separate estimates for women of zero parity and those with previous live births; the latter may have received anti-smoking advice during prior pregnancies.

II. Background

Pregnancy smoking greatly varies across socio-economic strata. Figure 1 shows national rates from 1989-2004 for all women as well as non-Hispanic whites, non-Hispanic blacks, and Hispanics (NCHS, 2006). While prevalence steadily declined across all groups, the disparities are striking and show no signs of narrowing: in 2004, for example, prenatal smoking among whites was 13.8 percent, exceeding black and Hispanic rates by 5.4 and 2.6 percentage points. Slicing the population by education (Figure 2) shows that women with 9-11 years of education have the highest rates of smoking (23.7 percent in 2004), followed by women with 12 years of schooling (14.9 percent). Only 1.5 percent of the most highly educated women (16 or more years of schooling) smoked during pregnancy. Figure 3 shows trends by mother's age: 15-24 year-olds smoke the most (14.2-15.5 percent), while those 30 and older smoke less (6.1-7.2 percent).

Other researchers using birth certificates or other data sources have found similar patterns. Kahn, et al. (2002) examine the 1988 National Maternal and Infant Health Survey (NMIHS) – administered to nationally representative samples of mothers and medical providers[5] – and find that less-educated women are more likely to smoke before delivery, less likely to quit during pregnancy, and more likely to relapse after delivery. Ventura, et al. (2003) look at birth certificates in 2000 from 49 states (California excluded) and the District of Columbia. They find that prenatal smoking rates are higher among women in their teens and early twenties, Non-Hispanic whites and Native Americans, high school dropouts, unmarried women, and late prenatal care seekers.

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[5] http://www.cdc.gov/nchs/about/major/nmihs/abnmihs.htm

Buescher (1997) analyzes North Carolina birth certificates and finds the highest rates of prenatal smoking among American Indians, white women, those who were unmarried, receiving Medicaid or WIC, and those with less than 12 years of schooling. Fingerhut, et al. (1990) use the 1986 Linked Telephone Survey, a reinterview of 1,550 white women who were previous respondents in the 1985 National Health Interview Survey (NHIS), and find similar socio-economic characteristics: pregravid smoking is more likely among women who are younger, unmarried, and have less education.

A significant proportion (estimates range from below 40% to more than half) of pre-pregnancy smokers who quit do so as soon as they learn they are pregnant (Solomon, et al., 2004; Ockene, et al., 2002; Fingerhut, et al., 1990). Solomon, et al. (2004) review previous work and find that, compared with women who have private insurance, women who obtain prenatal care from public clinics have lower spontaneous quit rates. The authors also note that spontaneous quitters tend to be more highly educated, have higher incomes, be married, be new mothers, have a planned pregnancy, intend to breastfeed, and were lighter pregravid smokers. Yu, et al. (2002) study the 1998 NHIS and write that non-Hispanic whites, young women, unmarried women, those with less than a high school education, and have below-poverty incomes, have higher prenatal smoking rates. Women with 16 or more years of schooling, are married, or are at and above the poverty level are more likely to attempt quitting.

These prevalence patterns are largely reflected within our study sample of WIC participants. Pregravid and prenatal smoking rates are highest for Non-Hispanic whites, unmarried women, those with less than 12 years of education, mothers younger than 25, women on Medicaid, and those who did not receive prenatal care.

Efficacy of Smoking Interventions

Public maternity health clinics, many of which offer on-site WIC programs, are promising venues to encourage quitting among poor women. However, smoking cessation projects described in the literature yield mixed results. In 1986, Colorado, Maryland, and Missouri participated in the Smoking Cessation in Pregnancy project (Kendrick, et al, 1995). Pregnant smokers on WIC and in public health clinics received short counseling sessions and self-help literature written at a sixth-grade reading level. In the eighth month of pregnancy, women receiving such interventions had significantly higher self-reported quit rates compared with women in the control group (13% versus 9.5%). However, "verified" quit rates, obtained by analyzing urine specimens for cotinine, were not significantly different (5.9% versus 6.1%).

In a randomized trial, Secker-Walker, et al. (1995) look at the impact of having doctors and nurses include smoking cessation advice in prenatal care. They also analyze urine specimens to verify quitting. They find no significant effects of counseling in preventing relapses during pregnancy or at the six-week postpartum follow-up.

Another trial randomly assigned pregnant women who had smoked earlier in pregnancy but had quit by the first prenatal visit to either receive usual physician advice or more structured advice along with individual relapse counseling (Secker-Walker, et al., 1998). Researchers found no difference either in relapse rates during pregnancy, or at one year postpartum.

Windsor, et al (1985), however, reported higher verified quit rates for pregnant smokers receiving interventions. They studied 309 pregnant smokers at public health clinics in Birmingham, Alabama, randomized among three groups. The two treatment groups received counseling sessions and an American Lung Association booklet titled *Because You Love Your Baby*. However, one treatment group was also given the ALA's Freedom From Smoking manual; the other received *A Pregnant Woman's Self-Help Guide to Smoking*. Saliva thiocyanate (SCN) was assessed to verify smoking status. The women in this study were told that SCN would confirm cigarette smoke exposure. Only 3 percent false negatives in the sample were reported. Women who received *A Pregnant Woman's Self-Help Guide to Smoking* had significantly higher quit rates than the control group (14% versus 2%).

A more recent program randomized six Massachusetts-based community health centers that served WIC participants to either special intervention or usual care (Pbert, et al., 2004). Intervention clinics provided tailored cessation services and systematic follow-ups. A smoker was considered to have quit at the end of pregnancy if she reported not smoking within 30 days before delivery. The mean abstinence rate in intervention clinics (26%) significantly exceeded that in usual care clinics (12%). This effect, however, was not sustained at 3- and 6-month postpartum follow-ups.

In their summary of the literature on prenatal smoking interventions, Floyd, et al. (1993) note that the effective programs used "designated providers" who were enlisted to specifically provide anti-smoking advice. The authors note 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.

There is little evidence that WIC, as currently structured, can provide the intensive services that effective intervention programs entail. A GAO (2001) report to

Congress, while not specifically focused on smoking cessation, found that among six WIC agencies studied, individual counseling averaged 4 to 17 minutes. Agencies are mandated to offer only two sessions every six months. However, recipients are not required to attend any sessions, whether they are nutrition- or smoking-oriented (Fox, et al., 2004; Besharov and Germanis, 2000).

III. Data

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.

Access to PNSS records was granted on a state-by-state basis. We requested data from ten 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 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 is further restricted to women 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 five 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 four 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 five weeks of conception. These exclusions result in over 150,000 women removed from the regression samples. Table 1 shows the set of states and years used in our various analyses.

Quality of the smoking measures

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 three months before pregnancy; (2) current smoking and number of cigarettes per day; (3) a multiple-choice change question, which 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. 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 17,000 women (less than 1 percent of the regression sample or 2.3 percent 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 three 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 differ when North Carolina is excluded from the sample.) We also construct the variable "Smoked at any point during pregnancy" by combining responses to the prenatal WIC and late-pregnancy smoking questions. Table 2 shows how each of our smoking outcomes was constructed based on original PNSS variables.

Research by Kharrazi, et al. (1999) 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. 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 (Mullen, et al. 1999). 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.

Table 3 juxtaposes smoking in our PNSS population with rates calculated from other data sources. (We exclude Virginia, for which we only have 2004 data, from these comparisons.) In the first panel, we compare PNSS pregravid smoking rates with those among non-pregnant female respondents from the Behavioral Risk Factor Surveillance System (BRFSS), an ongoing, nationally representative, telephone survey.[6] We first compare all women ages 18-44. Except for Florida and New Jersey, PNSS women have higher pre-pregnancy smoking rates; among the other states, there are, as expected, large disparities between BRFSS and PNSS (as high as 18 percentage points). These differences greatly narrow – except, again, for FL and NJ - when we look at more socio-economically comparable subgroups of unmarried, less-educated women, who, in the BRFSS population, are likely to be eligible for WIC services.

The second panel of Table 3 compares PNSS pregnancy smoking to figures culled from Natality files. The patterns echo those found in the first panel, with PNSS pregnancy rates generally exceeding Natality figures, but greatly narrowed differences when comparisons are limited to unmarried, poorly educated women. In Table 4, we further break down the pregnancy smoking comparisons by race/ethnicity. Again, the

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

PNSS-Natality gaps in smoking diminish when limited to the more disadvantaged subgroups.

Florida, Indiana, and New Jersey are missing information on late-pregnancy and postpartum smoking. Data on these outcomes are also missing for women who do not return for a postpartum visit. Our main results hence rely on women with complete records from the remaining states: Michigan, Missouri, North Carolina, Ohio, and Virginia. However, we still present estimates (i.e. for pre-pregnancy and smoking at WIC prenatal) for samples that include Florida, Indiana, New Jersey, and women lost to follow-up in order to test the sensitivity of results to later exclusions.

IV. Empirical Model and Outcomes

We estimate a modified form of the following equation, a typical model in WIC evaluations:

(1) $$S = \alpha_0 + \alpha_1 WIC + X\beta + e.$$

S represents our primary outcome, smoking. The variable WIC is a dichotomous indicator of whether or not a woman enlisted in WIC during pregnancy. Comparison groups have typically consisted of eligible non-participants, such as Medicaid beneficiaries who are adjunctively eligible for WIC. **X** is a matrix of other relevant variables, including 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, year of infant's birth, and state of residence. Let e be the error term. The coefficient α_1, under ideal conditions, represents a treatment effect – that is, WIC's impact on its participants, the average effect of treatment on the treated (TOT).

For desirable outcomes, we would expect $\alpha_1 > 0$ and the reverse for adverse outcomes such as smoking. [7]

The problem with estimating α_1 has to do with selection or omitted variable bias. This exists when unobserved characteristics systematically sort individuals into participant and non-participant groups. We illustrate the problem below.

For now, let S_{1i} be the outcome when woman (i) participates in WIC and S_{0i} when she does not. *WIC* is the dichotomous indicator of participation. Following Heckman (1997), we further define

$S_{1i} = X\beta_1 + U_{1i}, E(U_{1i}) = 0$

$S_{0i} = X\beta_{01} + U_{0i}, E(U_{0i}) = 0$

$\Delta = S_{1i} - S_{0i}$

The average treatment effect (ATE) is the mean difference in the outcome with and without treatment on a person randomly drawn from the entire population of participants and non-participants:

$ATE_i = E(\Delta|X) = X\beta_1 - X\beta_0$

The average effect of treatment on the treated (TOT) is indicated as

$TOT_i = E(\Delta\ |X, WIC{=}1) = X\beta_1 - X\beta_0 + E(U_{1i} - U_{0i}|X, WIC{=}1)$

$= E(\Delta|X) + E(U_{1i} - U_{0i}|X, WIC{=}1)$

The outcome we observe is

$Si = WIC S_{1i} + (1\text{-}WIC)S_{0i}$

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[7] Because there has been little change in smoking over the years in 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. Consistent with the authors' findings, we did not find any significant difference in smoking after the settlement.

The fundamental difficulty when evaluating treatment effects is that an individual cannot be observed receiving and not receiving treatment. We can, however, observe individuals who receive treatment. Substituting for S_{1i} and S_{0i} and dropping the individual subscript we can write:

$$S = X\beta_0 + WIC(X\beta_1 - X\beta_0 + U_1 - U_0) + U_0$$

$$= X\beta_0 + WIC\,E(\Delta|X) + WIC(U_1 - U_0) + U_0$$

$$= X\beta_0 + WIC[E(\Delta\,|X, WIC{=}1) - E(U_1 - U_0|X, WIC{=}1) + U_1 - U_0] + U_0$$

$$= X\beta_0 + WIC[E(\Delta\,|X, WIC{=}1) + E(U_0|X, WIC{=}1) - E(U_0|X, WIC{=}0)] + U_0$$

Note that the coefficient on *WIC* is

$$E(\Delta\,|X, WIC{=}1) + [E(U_0|X, WIC{=}1) - E(U_0|X, WIC{=}0)]$$

$$= TOT + [E(U_0|X, WIC{=}1) - E(U_0|X, WIC{=}0)]$$

Two conditions are needed to identify the TOT. First, we need a counterfactual or an estimate of the outcome in the absence of treatment for those who were treated. Second, we must assume that the last term is zero. It is the term $[E(U_0|X, WIC{=}1) - E(U_0|X, WIC{=}0)]$ that Heckman (1997) identifies as selection bias, the difference in the base state between participants and non-participants. For example, $[E(U_0|X, WIC{=}1) - E(U_0|X, WIC{=}0)] > 0$ if WIC participants are favorably selected, e.g. more conscientious about their health. Regressing S on WIC in this case overestimates the TOT, inflating the program's estimated benefits. In the reverse scenario of adverse selection, $[E(U_0|X, WIC{=}1) - E(U_0|X, WIC{=}0)] < 0$; women prone to engage in detrimental behaviors may be more likely to seek WIC services, underestimating the TOT.

A popular strategy for minimizing the selection bias term is instrumental variables estimation, which entails choosing an instrument that is highly correlated with the regressor of interest (*WIC*) and uncorrelated with the error term. In our case, we lack a suitable instrument and resort to a rich set of controls, as well as separate estimates by more homogeneous groups: our large sample allows us to look at effects for various strata, including race/ethnicity and parity.

If earlier WIC enrollment allows a participant to receive the smoking message earlier and more frequently, then we should see a greater impact among women who sign up early in pregnancy compared to those who are not counseled until the third trimester. Information on the timing of WIC registration lets us test for such a dose-response effect. We therefore estimate an expanded version of Equation (1):

$$S = \alpha_0 + \alpha_1 WIC_1 + \alpha_2 WIC_2 + X\beta + e. \qquad (2)$$

The WIC variables indicate the trimester of pregnancy a woman joined the program. Assuming lengthier WIC exposure is more beneficial, we should expect $\alpha_1 < \alpha_2 < 0$ for our smoking outcomes (and the reverse for desirable outcomes). Our omitted group, in lieu of eligible non-participants, consists of women who do not sign up for WIC until their third trimester. Thus we compare prenatal participants to women who are not just eligible, but who know of WIC and have elected to enroll.

For dichotomous outcomes, we use maximum-likelihood probit and report marginal effects (the effect when WIC changes from 0 to 1) for an average participant. For continuous outcomes such as number of cigarettes smoked, we estimate Equation (2) using ordinary least squares.

Propensity Score Matching

Kotelchuck, et al. (1984) is an early example in WIC research of using matching to construct a plausible comparison group. Birth outcomes among WIC participants were compared with eligible non-participants, though the matching was only performed on four variables: age, race, parity, education, and marital status. A similar method was used by Stockbauer (1987) using a slightly larger set of variables. Both Stockbauer (1987) and Kotelchuck (1984), however, were limited to what was available on birth certificates; each study was therefore unable to account for other key variables such as income or receipt of services like Medicaid.

Our robustness check uses a richer set of covariates to obtain TOT estimates from propensity score matching, a method developed by Rosenbaum and Rubin (1983) for reducing selection bias. They proposed matching treated and untreated subjects on the propensity score, defined as the probability of being assigned to treatment given pre-treatment characteristics. The objective is to minimize bias by comparing outcomes between participants and non-participants who are as similar as possible (Rosenbaum and Rubin, 1983; Becker and Ichino, 2002). Adopting Becker and Ichino's (2002) notation, we define the propensity score as

$$p(X) = P(\mathit{WIC}=1|X) = E(\mathit{WIC}|X).$$

Assuming that treatment assignment is independent of potential outcomes, conditional on X, then treatment assignment and the potential outcomes are also independent conditional on p(X) (Rosenbaum and Rubin, 1983; Hirano and Imbens, 2001). Again, using Becker and Ichino's (2002) notation, the TOT can be expressed as:

$$TOT = E[S_1 - S_0|WIC=1]$$

$= E[E(S_1 – S_0|WIC=1), p(X)]$

$= E[E(S_1|WIC=1, p(X)) – E(S_0|WIC=0, p(X))|WIC=1]$

There are several ways to implement matching (Cameron and Trivedi, 2005). A popular method, nearest neighbor matching, uses the nearest untreated person as a counterfactual for every treated person. We use an algorithm developed by Becker and Ichino (2002), in which each treated unit is matched to the nearest control based on their propensity scores. The TOT is the average of the differences in outcomes, with weights dependent on the number of units in treated and control groups.

Another method is stratification matching, which divides the range of propensity scores into intervals such that the propensity scores of treated and control units within each interval do not significantly differ (Cameron and Trividi, 2005). Again we use a method developed by Becker and Ichino (2002). Their algorithm sorts the sample into k equally spaced intervals of the propensity score. The technique calls for the creation of smaller and smaller intervals until the average propensity scores of treated and controls in each interval no longer differ. The TOT is estimated by first getting the mean difference in outcomes within each block, then weighting the sum of these differences by the fraction of treated units in each.

Instead of matching on the propensity score, Hirano and Imbens (2001) suggest using it to weight regressions. This allows researchers to use all observations while giving greater weight to closer matches: regressions are weighted such that the weights equal 1 for the treated units and $p(X)/(1-p(X))$ for the controls.

V. Results

Our purpose is to estimate the influence of lengthier WIC enrollment on smoking among pregnant women. We first show yearly prevalence in pregnancy smoking for our unbalanced panel of eight states. We then look at mean smoking before pregnancy, during pregnancy, and at postpartum registration by the timing of prenatal enrollment. We bolster the credibility of these measures by presenting both unadjusted and adjusted differences in birth outcomes by smoking status. Afterwards, we show adjusted differences in smoking by the timing of WIC enrollment. Note however that smoking at pre-pregnancy and at prenatal registration cannot be impacted by WIC; any association is not a pathway but may instead be a marker for selection bias. It is late-pregnancy and postpartum smoking that the program may influence. Therefore, models of smoking at these points, conditional on pregravid status, plausibly represent the impact of WIC among smokers. Our results are further stratified by parity, as women who have previously given birth may have also received previous anti-smoking advice. We also look at estimates by intensity of pregravid smoking to see the influence is limited to either heavy or light smokers. To check the robustness of results, we present TOTs derived from three propensity score matching techniques.

Figure 4 depicts prenatal smoking by race/ethnicity in our eight states over 1995-2004. (Note that Ohio, which has relatively high rates, is included starting in 1999; which partly accounts for the bump in that year. Florida and New Jersey, with relatively low rates, enter in 2000.) The racial/ethnic disparities reflect those found in Figure 1. More than 40 percent of white women in our 2004 sample smoked during pregnancy, a rate almost 3 times that of blacks and ten times that of Hispanics.

In Figure 5, we look at mean rates of smoking by the woman's week of gestation when she enrolled in prenatal WIC. We look at patterns for three rates: pre-pregnancy smoking, whether the woman was smoking as of the WIC intake, and smoking at any time during pregnancy. Note that, as expected, pregravid rates are higher than the pregnancy figures. For all three measures, it is early enrollees who smoke the most, with rates dropping and then almost flattening from the second trimester to later in pregnancy.

Figure 6 adds two more measures: smoking during the last three months of pregnancy and postpartum. Three states (FL, IN, NJ) are dropped from this figure due to missing data for these added variables. Again, it is early enrollees who smoke the most, by any measure used. Rates of smoking are highest pre-pregnancy, drop to their lowest levels by late pregnancy, and rise after birth. For example, among 13th-week enrollees, 44 percent smoked before pregnancy, 24 percent smoked 3 months before delivery, and 26 percent smoked postpartum. Overall, among prenatal enrollees with complete records (excluding FL, IN, NJ), 44 percent of pregravid smokers quit by the last 3 months of pregnancy; this quit rate drops to 34 percent by the postpartum period. These patterns are consistent with findings from elsewhere in the literature. PRAMS data from 27 states in 2002 show that 23 percent of women surveyed smoked before pregnancy, 13 percent smoked in late pregnancy, and 18 percent smoked postpartum.[8] Kahn, et al. (2002), using their sample of 1988 NMIHS women, found a 56 percent pregnancy quit rate. By 17 months postpartum, however, only 15 percent of pregravid smokers were no longer smoking.

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[8] http://www.cdc.gov/PRAMS/2002PRAMSSurvReport/PDF/2k2PRAMS.pdf

Figure 7 shows differences in mean birth weights by the mother's smoking status before pregnancy. Although this measure does not directly influence birth weight, the difficulty of quitting and the stigma of admitting to smoking during pregnancy implies that pregravid smoking is a plausible indicator of pregnancy smoking status. As expected, infants of nonsmokers weigh more; the difference in 2004 was roughly 85 grams. We also look at two other birth outcomes by smoking status: indicators of low birth weight (LBW) and small-for-gestational-age (SGA). We see in Figures 8 and 9 that rates of LBW and SGA are much lower for nonsmokers.

Figures 10, 12, and 14 show birth outcome differences by smoking during pregnancy. The patterns are similar to Figures 7, 8, and 9, with nonsmokers having higher birth weights and lower rates of LBW and SGA. There is almost no change in these outcomes over time, which reflects the minimal declines in pregnancy smoking during the same period (see Figure 4). This lack of variation is striking, given the steep increases in cigarette prices from 1995 to 2004 (see Figure 16), but is consistent with Levy and Meara's (2006) finding that a 20 percent cigarette price shock brought about by the 1998 Master Settlement Agreement led to at most a 2 percent drop in the prenatal smoking rate.

Figure 11 also shows birth weight differences by pregnancy smoking. Here, however, we compare non-smokers to two groups: those who smoked as of prenatal WIC registration but did not smoke during the last three months of pregnancy, and those who smoked in both periods. Birth weights for both groups of smokers are lower than nonsmokers, but outcomes are improved for the women who had quit by late pregnancy. In 2004, there was a 172-gram difference in mean birth weight between nonsmokers and those who continued to smoke until late pregnancy. The nonsmokers' advantage narrowed to just 49 grams when compared to smokers who had quit by late pregnancy.

Figures 13 and 15 are similar to Figure 11, but look at mean LBW and SGA. Rates of both are much lower for nonsmokers. Quitting by late pregnancy narrows the disparities.

We seek to confirm these patterns by estimating adjusted differences in birth weight and two proxies for fetal growth: birth weight adjusted for gestation and SGA. Results are shown in Table 5 (see table footnote for covariates used). The outcome in Columns 1 and 2 is birth weight in grams, in Column 3 it is birth weight adjusted for gestation, and SGA in Column 4. While Column 1 includes all states, for consistency we limit the sample in Columns 2-4 to MO, NC, and OH. The reason is missing data on SGA (MI, VA) and smoking during the last three months of pregnancy (FL, IN, NJ) that force us to limit the SGA regressions to MO, NC, and OH. To eliminate variability of results due to differing samples, all outcomes in Columns 2-4 represent the same groups of women.

For all states, having smoked before pregnancy is associated with a 114-gram reduction in birth weight; this result is essentially unchanged when five states are dropped (Column 2) or when gestation is adjusted for (Column 3). Pregravid smoking is also correlated with a 5.9-percentage point increase in the rate of SGA, a 39% increase over a sample mean of 15.3 percent. Smoking at any time during pregnancy, over all states, leads to a 151-gram decline in birth weight. For the three remaining states, the difference is 135 grams; it is 132 grams after adjusting for gestation. The increase in SGA is 6.9 percentage points. Smoking during the last three months of pregnancy is associated with even worse disparities in outcomes: 194 grams for all states and 197 grams for MO, NC, and OH. The gestation-adjusted difference is 188 grams, while the increase in SGA is 10 percentage points. These results are consistent with ranges of 150-250 grams frequently found in the literature (Valero de Bernabe, et al., 2004).

We also detect a dose-response effect of smoking. For the eight-state sample, women who reported smoking 11 or more cigarettes a day either pre-pregnancy or at prenatal WIC registration had lighter infants compared to women who smoked fewer cigarettes. Similarly, rates of SGA for heavy smokers exceeded that of light smokers.

Table 6 is the first of our main results. We show adjusted differences in smoking by the timing of WIC enrollment for eight states. We include both those with complete records as well as women lost to follow-up. The first two rows in each panel show estimates of α_1 and α_2 from Equation 2. Results are also presented by race/ethnicity. We find that, consistent with Figures 5 and 6, first-trimester enrollment is associated with a greater likelihood of smoking. Among all women, first-trimester participants are 3 percentage points more likely to smoke pre-pregnancy, though among pregravid smokers, early enrollees tend to smoke 0.2 fewer cigarette/day than third-trimester women. Early enrollment is also associated with greater smoking at WIC intake or at any time during pregnancy. Among those who smoked at WIC registration, early enrollees smoked 0.1 fewer cigarette/day. Among blacks and Hispanics, it is early enrollees who tend to have greater spontaneous quit rates. Table 7 presents the same outcomes and states as Table 6, but without women lost to follow-up. There is almost no discernable difference in results.

Table 8 further drops FL, IN, and NJ, but adds outcomes that are missing for these three states: smoking during the last three months of pregnancy, and at postpartum registration. These are outcomes of particular interest because, unlike pregravid smoking or smoking at intake, they are potentially modifiable by early exposure to WIC. Note that (with the exception of pregravid smoking, smoking at any point during pregnancy and smoking at WIC prenatal among Hispanics) results for the first six outcomes change little compared with Tables 6 and 7. Among all women, only second-trimester enrollment appears to have an impact on late-pregnancy smoking. However, in the subgroup of pregravid smokers, both first- and second-trimester enrollment are associated with a 1.7-percentage point decline in late-pregnancy smoking (a 3 percent decrease). The first-trimester reductions are larger for blacks (3.8 percentage points) compared with whites (1.2 percentage points), and are insignificant for Hispanics. At postpartum registration, first-trimester women are more likely to report smoking. Limiting the analysis to pregravid smokers, however, shows a 1.3-percentage point reduction in smoking. Again, reductions are larger for blacks (3.5 percentage points) than whites (1.2 percentage points), and are insignificant for Hispanics.

Smoking differences by parity

We further stratify our estimates by parity. Presenting separate results for women of zero parity reduces bias from including mothers who may already have had greater exposure to anti-smoking education due to previous pregnancies or who have adjusted their smoking behaviors in response to previous birth outcomes. In Table 9, we see that, among first-time mothers, early enrollees smoke at far higher rates than third-trimester participants. First-trimester participants are 13 percent (6 percentage points) more likely to be pregravid smokers than are third-trimester enrollees. They are 17 percent more likely to smoke at any time during pregnancy or at registration. Among pregravid smokers, second-trimester enrollment reduces late-pregnancy smoking by 3 percent; the first-trimester coefficient is insignificant, except among blacks (a 6 percent decline) Similarly, among pre-pregnancy smokers, first-trimester enrollment has no impact on postpartum smoking except among black women (an 8 percent reduction).

Table 10 shows results for women with previous live births. In contrast to primiparas, early enrollees in this group tend to smoke less pre-pregnancy, at registration, or at any point during pregnancy. Among pregravid smokers in this group, first-trimester enrollment is associated with a 5 percent (2.8 percentage points) reduction in late-pregnancy smoking and a 3 percent (2.3 percentage points) decline in postpartum smoking.

Smoking differences by pregravid intensity

In Table 11, we limit our outcomes to late-pregnancy and postpartum smoking, but estimate separate results for light and heavy pregravid smokers. We find that first-trimester enrollment is correlated with a 4 percent decline (2.6 percentage points) in late-pregnancy smoking among heavy smokers. There is no effect among light smokers. For postpartum smoking, the percentage impact of first-trimester WIC is slightly greater among light smokers (2.2 percent) than among heavy smokers (1.8 percent).

Propensity score results

We present estimates for three propensity score techniques in Table 12 in order to check the robustness of earlier results. All our PSM estimates are comparisons between first-trimester participants (the treated group) and third-trimester enrollees (the control group). The reported TOTs are differences in smoking among first and third-trimester WIC enrollees with complete records for MI, MO, NC, OH, and VA. The TOTs are generally very close to one another, as well to the first-trimester coefficients in Table 8.

VI. Conclusion

Nationally, the percentage of pregnant women who smoke has reached an all-time low. However, low-income mothers continue to smoke at high rates; in some states, prenatal smoking among WIC participants is more than three times the national average, something that the WIC literature has paid scant attention to. Instead, there has been a disproportionate focus on a clinically unsubstantiated WIC-preterm birth pathway. Researchers who have linked WIC to more plausibly affected outcomes such as fetal growth have not shown a corresponding association between WIC and prenatal smoking, a significant risk factor for IUGR.

Using a set of rich covariates and data on the timing of WIC enrollment, this paper explores the relationship between earlier WIC participation and smoking among WIC mothers. Detailed smoking questions allow us to examine smoking at several points in time, starting from pre-pregnancy to postpartum registration. We demonstrate the credibility of our smoking variables by estimating adjusted differences in birth outcomes by smoking status. Infants born to smokers weigh less, by amounts that are consistent with ranges found in the clinical literature.

Among pregravid smokers, first-trimester participants are more likely to have quit by the last three months of pregnancy and as of postpartum registration. While this seems to point to a WIC effect, limiting the sample to first-time mothers eliminates the first-trimester effect on late-pregnancy smoking; the impact is significantly reduced for postpartum smoking. The exception is non-Hispanic black women; first and second-trimester enrollees in this group quit at significantly higher rates. Among pregravid smokers with previous live births, first and second-trimester enrollees also have significantly higher quit rates. However, it is difficult to specifically ascribe this to the WIC program, as these mothers may have received anti-smoking advice from earlier pregnancies or may have changed their behavior based on prior adverse birth outcomes.

Overall, we do not find a consistent impact on smoking at points WIC can influence: in the last three months of pregnancy or at postpartum. We do find that women who enroll in the first and second trimesters are more likely to smoke before pregnancy and as of WIC registration compared with third-trimester enrollees. WIC cannot affect smoking before a woman enrolls. However, the greater propensity of first and second-trimester enrollees to smoke points to an opportunity for the program to systematically influence significant numbers of smokers early in their pregnancies.

Table 1. Distribution of Prenatal WIC Participants by States and Timing of 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)	132,722	140,701	74,201	347,624
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	672,042	737,159	409,104	1,818,305

Table 2. Derivation of Smoking Outcomes

Smoking Outcome	Variables Used	
	CDC States	North Carolina
(1) Smoked 3 months before pregnancy	Combined responses to questions on: - Average daily number of cigarettes smoked three months before pregnancy - Change in smoking from pre-pregnancy to WIC visit*	Combined responses to questions on: - Average daily number of cigarettes smoked three months before pregnancy - Change in smoking from pre-pregnancy to WIC visit*
(2) Cigarettes smoked 3 months before pregnancy	Number of cigarettes smoked three months before pregnancy	Number of cigarettes smoked three months before pregnancy
(3) Quit as soon as pregnant	Change in smoking from pre-pregnancy to WIC visit*	Change in smoking from pre-pregnancy to WIC visit*
(4) Smoked at prenatal WIC visit	Combined responses to questions on: - Average daily number of cigarettes smoked as of WIC - Change in smoking from pre-pregnancy to WIC visit*	Combined responses to questions on: - Average daily number of cigarettes smoked as of WIC - Change in smoking from pre-pregnancy to WIC visit*
(5) Cigarettes smoked as of prenatal WIC	Average daily number of cigarettes smoked as of WIC	Average daily number of cigarettes smoked as of WIC
(6) Smoked during the last 3 months of pregnancy	Average daily number of cigarettes smoked during the last three months of pregnancy	Used smoked during pregnancy based on the birth certificate as a proxy
(7) Smoked at any time during pregnancy	Combined results from (5) and (6)	Combined results from (5) and (6)
(8) Smoked postpartum	Combined responses to questions on: - Average daily number of cigarettes smoked as of postpartum WIC - Change in smoking from birth to postpartum*	Change in smoking from pre-pregnancy to postpartum*

* For CDC states (FL, IN, MI, MO, NJ, OH, VA), possibles responses to the smoking change questions are: (1) no change - still smoking; (2) decreased smoking; (3) stopped completely; (4) tried but failed to stop; (5) increased smoking; (6) n/a, did not smoke; (7) unknown change. For North Carolina, the choices are: (1) smokes same amount; (2) stopped completely; (3) tried to stop but failed; (4) n/a, did not smoke; (5) unknown change.

Table 3. Smoking Among Women 18-44 Years Old[#]

Smoked Before Pregnancy

	All				Unmarried, Education<= 12 Years			
	PNSS*		BRFSS[##]		PNSS*		BRFSS[##]	
	%	N	%	N	%	N	%	N
FL (2000-2004)	16.4	226,262	27.0	6,158	19.5	118,619	38.0	1,213
IN (1995-2004)	47.0	217,839	31.1	9,049	54.3	85,606	50.0	1,836
MI (1996-2004)	47.5	332,386	29.5	7,676	56.0	164,133	49.2	1,357
MO (1995-2004)	44.3	262,064	30.9	8,428	51.7	140,469	49.0	1,636
NC (1996-2003)	39.9	319,929	26.3	9,180	43.7	136,056	39.4	1,793
NJ (2000-2004)	14.6	108,795	22.0	9,176	18.3	49,039	37.1	1,479
OH (1999-2004)	48.3	270,236	32.5	5,569	55.2	155,960	50.4	1,290

Smoked at Any Time During Pregnancy

	All				Unmarried, Education<= 12 Years			
	PNSS*		Natality		PNSS*		Natality	
	%	N	%	N	%	N	%	N
FL (2000-2001)	12.1	28,458	9.4	379,796	14.2	13,528	15.9	104,566
IN (1995-2001)	35.3	147,763	20.3	550,157	40.6	74,230	39.7	131,144
MI (1996-2001)	33.9	218,316	16.5	746,014	40.7	107,628	33.0	173,743
MO (1995-2001)	36.9	181,512	18.9	483,540	43.5	94,725	36.5	112,517
NC (1996-2001)	31.3	237,485	14.7	621,172	35.0	99,442	25.1	145,132
NJ (2000-2001)	9.3	41,310	9.5	216,442	12.1	22,137	21.1	41,271
OH (1999-2001)	47.1	131,671	18.9	426,663	53.6	75,399	38.1	104,698

[#] Based on women with known smoking status

[##] Behavioral Risk Factor Surveillance System

* Prenatal WIC enrollees only

Table 4. Rates of Smoking During Pregnancy Among Women 18-44 Years Old, by Race/Ethnicity#

All Women

	White		Black		Hispanic	
	PNSS	**Natality**	**PNSS**	**Natality**	**PNSS**	**Natality**
FL (2000-2001)	27.9	15.0	4.2	4.4	2.1	2.1
IN (1995-2001)	42.3	22.1	19.3	16.3	8.4	6.5
MI (1996-2001)	41.1	17.1	22.5	15.5	13.1	16.6
MO (1995-2001)	43.3	20.4	21.9	14.1	9.5	7.3
NC (1996-2001)	44.6	17.6	22.1	11.7	10.3	1.8
NJ (2000-2001)	24.9	11.1	10.3	13.3	3.2	5.5
OH (1999-2001)	55.6	20.1	30.2	15.9	22.2	11.7

Unmarried, Education <=12 Years

	White		Black		Hispanic	
	PNSS	**Natality**	**PNSS**	**Natality**	**PNSS**	**Natality**
FL (2000-2001)	32.9	34.6	5.0	6.4	2.8	4.0
IN (1995-2001)	49.5	49.5	21.8	22.6	10.5	9.4
MI (1996-2001)	50.9	42.6	26.2	21.9	18.8	28.5
MO (1995-2001)	53.6	47.2	24.7	19.0	12.1	12.5
NC (1996-2001)	56.2	44.0	25.9	17.2	11.0	2.2
NJ (2000-2001)	34.5	40.7	13.2	22.5	4.2	8.3
OH (1999-2001)	64.4	46.6	34.5	22.4	29.1	19.5

Based on women with known smoking status

* Prenatal WIC enrollees only; VA data only available for 2004.

Table 5. 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**	-112.6**	0.059**
Cigarettes/day before pregnancy (ref: no cigarettes/day)				
1-10	-83.5**	-89.2**	-90.9**	0.051**
11-20	-141.7**	-144.7**	-144.4**	0.082**
21+	-201.6**	-201.7**	-191.9**	0.115**
Unknown	-55.1**	-51.9**	-51.7**	0.031**
Smoked at any time during pregnancy	-154.1**	-141.6**	-137.9**	0.072**
Smoked as of prenatal WIC	-150.5**	-135.3**	-132.1**	0.069**
Cigarettes/day at prenatal WIC (ref: no cigarettes/day)				
1-10	-164.6**	-164.5**	-159.3**	0.087**
11-20	-233.8**	-231.5**	-219.1**	0.130**
21+	-237.7**	-215.5**	-210.0**	0.132**
Unknown	-101.1**	-78.8**	-79.7**	0.044**
Mean dep var	3,281.8	3,266.5	3,266.5	0.153
N	1,670,877	854,014	854,014	854,014
Smoked last three months of pregnancy##	-194.0**	-196.6**	-187.7**	0.100**
Mean dep var	3,278.9	3,266.5	3,266.5	0.153
N	1,123,915	854,014	854,014	854,014

+ p<0.10, * p<0.05, ** p<.01

Data missing for FL, IN, NJ.

Differences adjusted for race/ethnicity, age, marital status, education level, parity, pregravid BMI, income categories and Medicaid/TANF/Food Stamp participation. All regressions include state and year fixed effects. Standard errors are adjusted for clustering at the state-year level.

Table 6. Adjusted Differences in Smoking Among Prenatal WIC Enrollees with Complete Records or are Lost to Follow-Up, by Trimester of Enrollment[#]

	Smoked 3 Months Before Pregnancy				Cigarettes/Day Among Pregravid Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.027**	0.019**	0.037**	0.016**	-0.2**	-0.2**	-0.1	0.1
Second trimester	-0.002	-0.005**	0.005**	-0.002	0.0	0.0	-0.1*	0.1
Mean dep var	0.394	0.545	0.247	0.103	16.0	17.4	10.3	11.0
N	1,818,305	1,019,506	500,448	247,088	646,243	518,847	99,031	18,577

	Smoked at Any Time During Pregnancy				Quit as soon as Pregnant (Among Pregravid Smokers)			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.026**	0.030**	0.020**	0.007**	-0.006	-0.013*	0.032**	0.025+
Second trimester	0.002+	0.004*	0.003	-0.001	-0.004	-0.006	0.004	0.006
Mean dep var	0.31	0.436	0.188	0.065	0.321	0.321	0.314	0.374
N	1,818,305	1,019,506	500,448	247,088	641,339	505,906	103,855	21,294

	Smoked at WIC Prenatal				Cigarettes/Day Among WIC Prenatal Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.023**	0.027**	0.017**	0.006*	-0.1**	-0.1*	-0.3*	0.2
Second trimester	0.003*	0.004*	0.003+	-0.001	0.1	0.1	-0.1	0.3
Mean dep var	0.289	0.410	0.169	0.061	8.7	9.2	6.2	6.6
N	1,818,305	1,019,506	500,448	247,088	344,900	284,165	48,507	6,897

+ p<0.10, * p<0.05, ** p<.01

[#] Women with available data on pregravid smoking, smoking at prenatal WIC, and smoking at any time during pregnancy.

Differences adjusted for race/ethnicity, age, marital status, education level, parity, pregravid BMI, income categories, Medicaid/TANF/Food Stamp participation, and household size. All regressions include state and year fixed effects. Standard errors are adjusted for clustering at the state-year level.

Table 7. Adjusted Differences in Smoking Among Prenatal WIC Enrollees With Complete Records, by Trimester of Enrollment[#]

	Smoked 3 Months Before Pregnancy				Cigarettes/Day Among Pregravid Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.027**	0.019**	0.038**	0.017**	-0.2**	-0.2**	-0.1	0.1
Second trimester	-0.002+	-0.005**	0.005*	-0.001	0.0	0.0	-0.1*	0.11
Mean dep var	0.394	0.545	0.245	0.102	16.0	17.3	10.2	10.9
N	1,768,970	996,870	481,502	241,230	631,073	507,911	95,377	18,248

	Smoked at Any Time During Pregnancy				Quit as soon as Pregnant (Among Pregravid Smokers)			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.026**	0.031**	0.021**	0.007**	-0.006	-0.013*	0.029**	0.022+
Second trimester	0.003*	0.004*	0.003	-0.001	-0.005	-0.006	0.003	0.005
Mean dep var	0.310	0.436	0.185	0.064	0.322	0.321	0.317	0.381
N	1,768,970	996,870	481,502	241,230	624,125	494,855	99,157	20,459

	Smoked at WIC Prenatal				Cigarettes/Day Among WIC Prenatal Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.023**	0.027**	0.018**	0.007**	-0.1**	-0.1*	-0.2*	0.0
Second trimester	0.003*	0.004*	0.003+	-0.001	0.1	0.1	-0.1	0.3
Mean dep var	0.289	0.410	0.168	0.06	8.7	9.2	6.2	6.5
N	1,768,970	996,870	481,502	241,230	334,940	276,785	46,239	6,752

+ p<0.10, * p<0.05, ** p<.01

[#] Excludes those lost to follow-up.

See footnote to Table 6 for a list of covariates.

Table 8. Adjusted Differences in Smoking Among Prenatal WIC Enrollees With Complete Records, by Trimester of Enrollment: MI, MO, NC, OH, VA

	Smoked 3 Months Before Pregnancy				Cigarettes/Day Among Pregravid Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.022**	0.014**	0.036**	0.008	-0.2**	-0.2**	-0.1	0.4
Second trimester	-0.004*	-0.005**	0.005	-0.010**	-0.1	0.0	-0.2**	0.2
Mean dep var	0.445	0.559	0.288	0.165	15.8	17.1	10.1	11.2
N	1,146,832	703,624	322,595	88,658	452,581	363,612	72,469	9,231

	Smoked at Any Time During Pregnancy				Quit as soon as Pregnant (Among Pregravid Smokers)			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.025**	0.027**	0.022**	0.006	0.000	-0.005	0.032**	0.033*
Second trimester	0.001	0.003	0.002	-0.007*	0.001	0.000	0.008+	0.025+
Mean dep var	0.365	0.467	0.226	0.117	0.326	0.332	0.306	0.312
N	1,146,832	703,624	322,595	88,658	458,012	360,972	77,059	12,114

	Smoked at WIC Prenatal				Cigarettes/Day Among WIC Prenatal Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.021**	0.023**	0.018**	0.005	-0.1	-0.0	-0.3*	0.6
Second trimester	0.001	0.002	0.002	-0.007*	0.1*	0.1*	-0.2	0.8+
Mean dep var	0.337	0.434	0.201	0.108	8.6	9.1	6.2	7.5
N	1,146,832	703,624	322,595	88,658	230,512	188,851	34,344	3,356

	Smoked Last 3 Months of Pregnancy				Smoked Last 3 Months of Pregnancy: Pregravid Smokers Only			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.000	-0.001	0.002	0.003*	-0.017**	-0.012**	-0.038**	0.011
Second trimester	-0.010**	-0.012**	-0.007**	-0.002+	-0.017**	-0.013**	-0.031**	-0.001
Mean dep var	0.250	0.337	0.125	0.044	0.561	0.603	0.435	0.268
N	1,146,832	703,624	322,595	88,658	510,264	393,491	92,886	14,649

	Smoked Postpartum				Smoked Postpartum: Pregravid Smokers Only			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	0.005**	0.002	0.009**	0.005+	-0.013**	-0.008**	-0.035**	0.000
Second trimester	-0.008**	-0.009**	-0.004*	-0.004*	-0.014**	-0.010**	-0.028**	-0.006
Mean dep var	0.302	0.399	0.167	0.079	0.656	0.694	0.540	0.442
N	1,146,832	703,624	322,595	88,658	510,264	393,491	92,886	14,649

+ p<0.10, * p<0.05, ** p<.01

See footnote to Table 6 for a list of covariates.

Table 9. Adjusted Differences in Smoking Among Zero Parity Prenatal WIC Enrollees With Complete Records, by Trimester of Enrollment: MI, MO, NC, OH, VA

	Smoked 3 Months Before Pregnancy				Cigarettes/Day Among Pregravid Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment: (Ref: Third								
First trimester	0.057**	0.049**	0.068**	0.012	0.0	0.0	-0.2	0.5
Second trimester	0.015**	0.012**	0.024**	-0.003	0.0	0.1	-0.3**	0.3
Mean dep var	0.460	0.584	0.259	0.180	15.0	16.1	9.1	10.9
N	545,713	344,371	147,325	39,174	224,831	187,045	29,287	4,768

	Smoked at Any Time During Pregnancy				Quit as soon as Pregnant (Among Pregravid Smokers)			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment: (Ref: Third								
First trimester	0.061**	0.070**	0.044**	0.011+	-0.007	-0.014	0.047**	0.03
Second trimester	0.020**	0.025**	0.015**	-0.002	-0.003	-0.007	0.023**	0.028
Mean dep var	0.352	0.457	0.184	0.118	0.363	0.364	0.357	0.363
N	545,713	344,371	147,325	39,174	226,901	185,026	31,939	5,967

	Smoked at WIC Prenatal				Cigarettes/Day Among WIC Prenatal Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment: (Ref: Third								
First trimester	0.053**	0.062**	0.037**	0.009	-0.1+	-0.1	-0.8*	0.3
Second trimester	0.018**	0.023**	0.014**	-0.001	-0.0	0.0	-0.7**	0.7
Mean dep var	0.323	0.421	0.164	0.109	7.5	7.8	5.3	7.0
N	545,713	344,371	147,325	39,174	104,335	89,772	11,253	1,498

	Smoked Last 3 Months of Pregnancy				Smoked Last 3 Months of Pregnancy: Pregravid Smokers Only			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment: (Ref: Third								
First trimester	0.022**	0.026**	0.016**	0.005*	-0.001	0.002	-0.020*	0.017
Second trimester	0.000	0.000	0.001	-0.002	-0.014**	-0.010**	-0.029**	-0.012
Mean dep var	0.227	0.312	0.086	0.043	0.493	0.534	0.332	0.241
N	545,713	344,371	147,325	39,174	251,000	201,246	38,132	7,055

	Smoked Postpartum				Smoked Postpartum: Pregravid Smokers Only			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment: (Ref: Third								
First trimester	0.029**	0.033**	0.023**	0.005	-0.001	0.006+	-0.037**	-0.007
Second trimester	0.005*	0.005+	0.006*	-0.001	-0.010**	-0.005+	-0.030**	-0.01
Mean dep var	0.288	0.384	0.133	0.080	0.606	0.640	0.474	0.414
N	545,713	344,371	147,325	39,174	251,000	201,246	38,132	7,055

+ p<0.10, * p<0.05, ** p<.01

See footnote to Table 6 for a list of covariates.

Table 10. Adjusted Differences in Smoking Among Prenatal WIC Enrollees With Complete Records and Previous Live Births, by Trimester of Enrollment: MI, MO, NC, OH, VA

	Smoked 3 Months Before Pregnancy				Cigarettes/Day Among Pregravid Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	-0.007**	-0.020**	0.008+	0.002	-0.3**	-0.4**	-0.1	0.2
Second trimester	-0.017**	-0.023**	-0.008*	-0.016**	-0.1*	-0.1+	-0.1	0.1
Mean dep var	0.43	0.532	0.312	0.153	16.5	18.1	10.9	11.6
N	539,267	346,910	169,522	48,654	203,486	169,372	41,438	4,354

	Smoked at Any Time During Pregnancy				Quit as soon as Pregnant (Among Pregravid Smokers)			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	-0.004	-0.013**	0.003	0.000	0.005	0.002	0.025**	0.038*
Second trimester	-0.014**	-0.018**	-0.008*	-0.013**	0.004	0.006	0.001	0.024
Mean dep var	0.373	0.473	0.259	0.115	0.289	0.292	0.268	0.263
N	539,267	346,910	169,522	48,654	207,140	168,863	43,406	6,037

	Smoked at WIC Prenatal				Cigarettes/Day Among WIC Prenatal Smokers			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	-0.004*	-0.013**	0.001	0.000	-0.0	-0.0	-0.2	0.7
Second trimester	-0.012**	-0.017**	-0.007*	-0.012**	0.1+	0.2**	0.0	0.9+
Mean dep var	0.345	0.442	0.230	0.106	9.5	10.3	6.7	7.9
N	539,267	346,910	169,522	48,654	112,717	95,627	22,353	1,819

	Smoked Last 3 Months of Pregnancy				Smoked Last 3 Months of Pregnancy: Pregravid Smokers Only			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	-0.017**	-0.026**	-0.010**	0.002	-0.028**	-0.024**	-0.043**	0.007
Second trimester	-0.017**	-0.022**	-0.012**	-0.003+	-0.017**	-0.014**	-0.029**	0.008
Mean dep var	0.268	0.361	0.159	0.045	0.629	0.679	0.509	0.293
N	539,267	346,910	169,522	48,654	232,127	184,720	52,828	7,466

	Smoked Postpartum				Smoked Postpartum: Pregravid Smokers Only			
	All	White	Black	Hispanic	All	White	Black	Hispanic
Timing of WIC Enrollment:								
(Ref: Third trimester)								
First trimester	-0.015**	-0.026**	-0.003	0.004	-0.022**	-0.020**	-0.032**	0.006
Second trimester	-0.017**	-0.023**	-0.011**	-0.007**	-0.016**	-0.014**	-0.026**	-0.004
Mean dep var	0.311	0.410	0.193	0.077	0.697	0.747	0.582	0.465
N	539,267	346,910	169,522	48,654	232,127	184,720	52,828	7,466

+ p<0.10, * p<0.05, ** p<.01

See footnote to Table 6 for a list of covariates.

Table 11. Adjusted Differences in Smoking Among Prenatal WIC Enrollees With Complete Records, by Trimester of Enrollment and Pregravid Smoking Intensity: MI, MO, NC, OH, VA

	Smoked Last 3 Months of Pregnancy	
	1-10 Cigarettes/Day Pre-Pregnancy	**11+ Cigarettes/Day Pre-Pregnancy**
Timing of WIC Enrollment:		
(Ref: Third trimester)		
First trimester	-0.008	-0.026**
Second trimester	-0.016**	-0.018**
Mean dep var	0.437	0.714
N	204,388	247,888

	Smoked Postpartum	
	1-10 Cigarettes/Day Pre-Pregnancy	**11+ Cigarettes/Day Pre-Pregnancy**
Timing of WIC Enrollment:		
(Ref: Third trimester)		
First trimester	-0.013**	-0.014**
Second trimester	-0.017**	-0.010**
Mean dep var	0.577	0.777
N	204,388	247,888

+ p<0.10, * p<0.05, ** p<.01

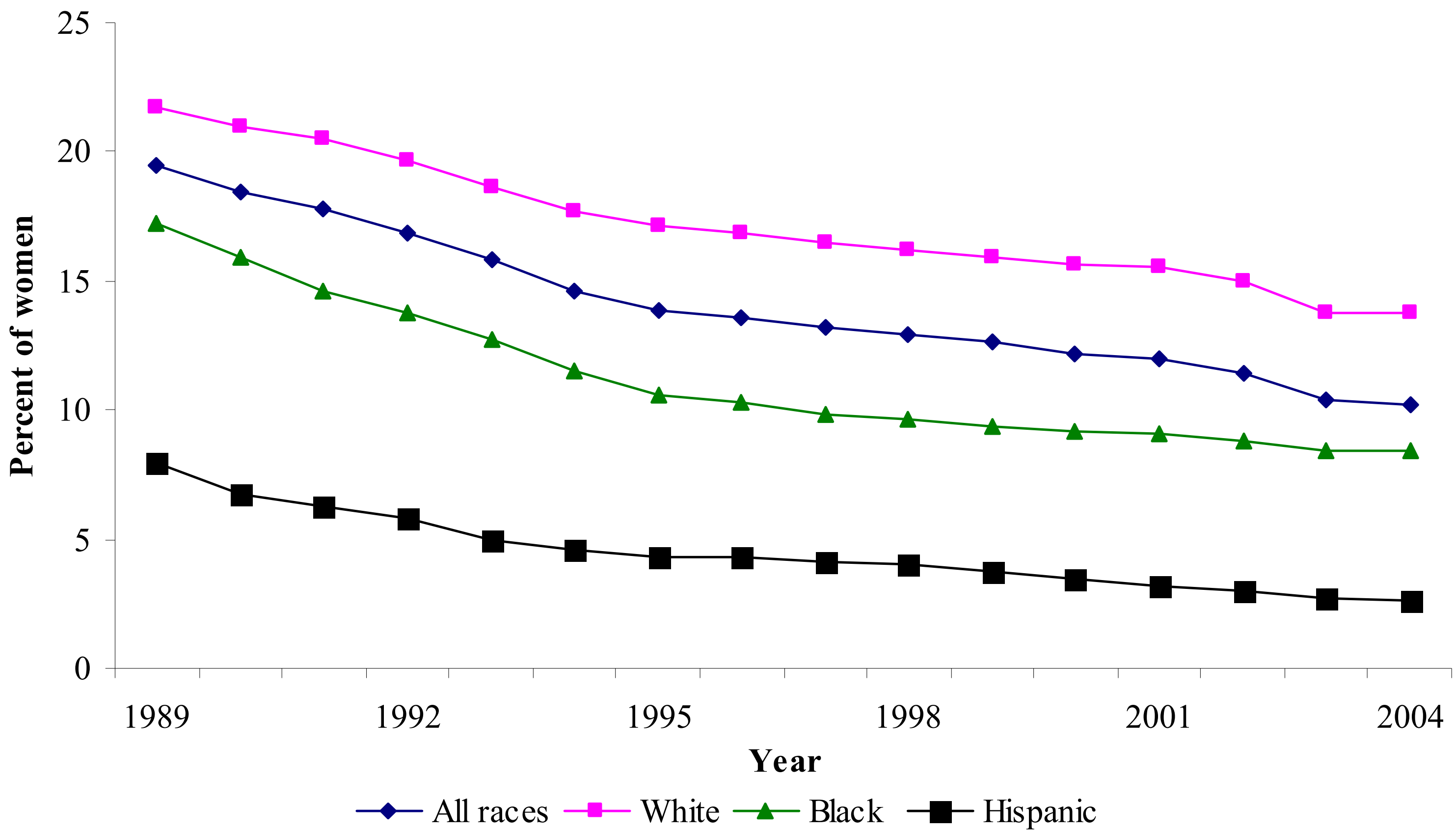
See footnote to Table 6 for a list of covariates.

Table 12. Propensity Score Estimates of Adjusted Differences in Smoking Between First and Third-Trimester WIC Enrollees With Complete Records: MI, MO, NC, OH, VA

	Hirano & Imbens	Nearest Neighbor	Stratification
(Ref: Third-trimester WIC)			
Smoked 3 months before pregnancy	0.018**	0.017**	0.023**
Smoked at any time during pregnancy	0.026**	0.024**	0.027**
Smoked at prenatal WIC	0.022**	0.021**	0.024**
Smoked last 3 months of pregnancy	0.003*	0.002	0.005**
Smoked last 3 months of pregnancy (pregravid smokers only)	-0.011**	-0.02**	-0.02**
Smoked postpartum	0.004*	0.004*	0.009**
Smoked postpartum (pregravid smokers only)	-0.013**	-0.014**	-0.012**

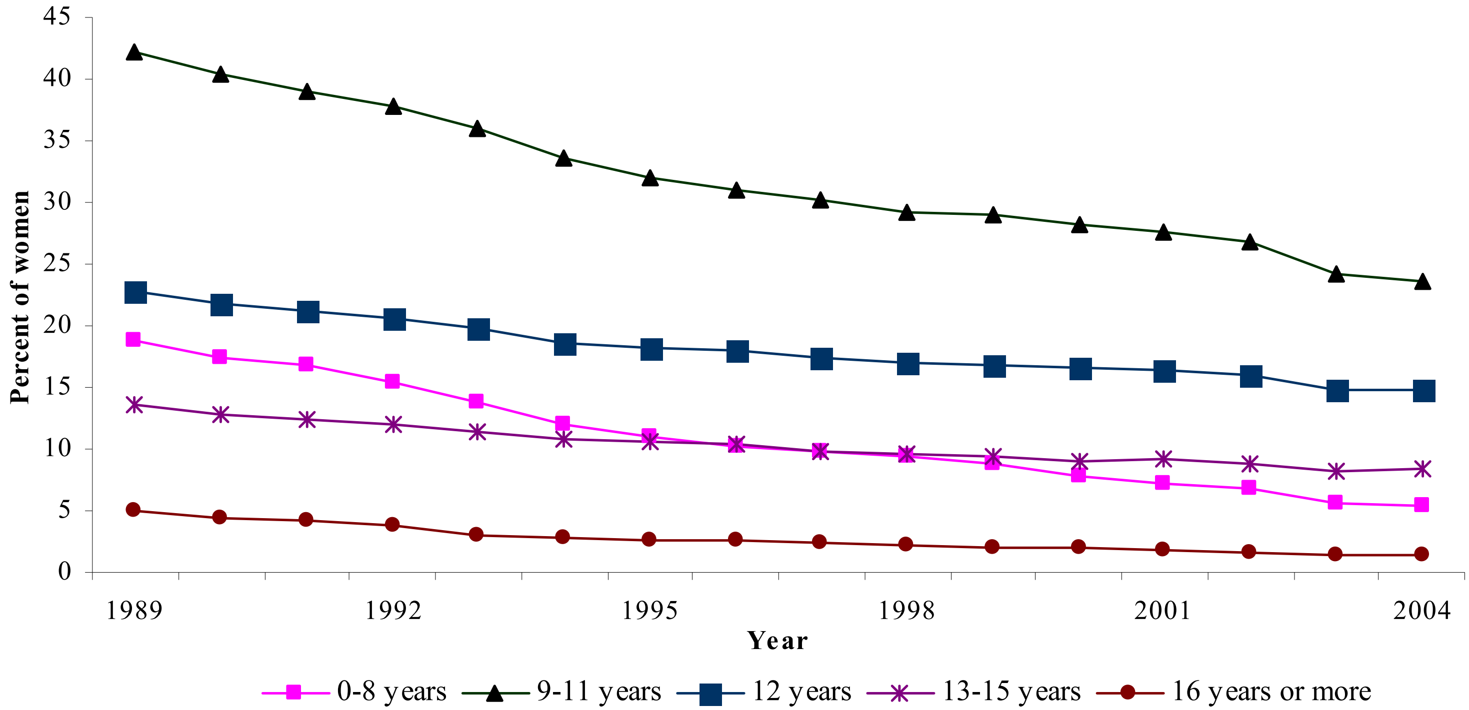
+ p<0.10, * p<0.05, ** p<.01

Figure 1. Prenatal Smoking in the United States, 1989-2004



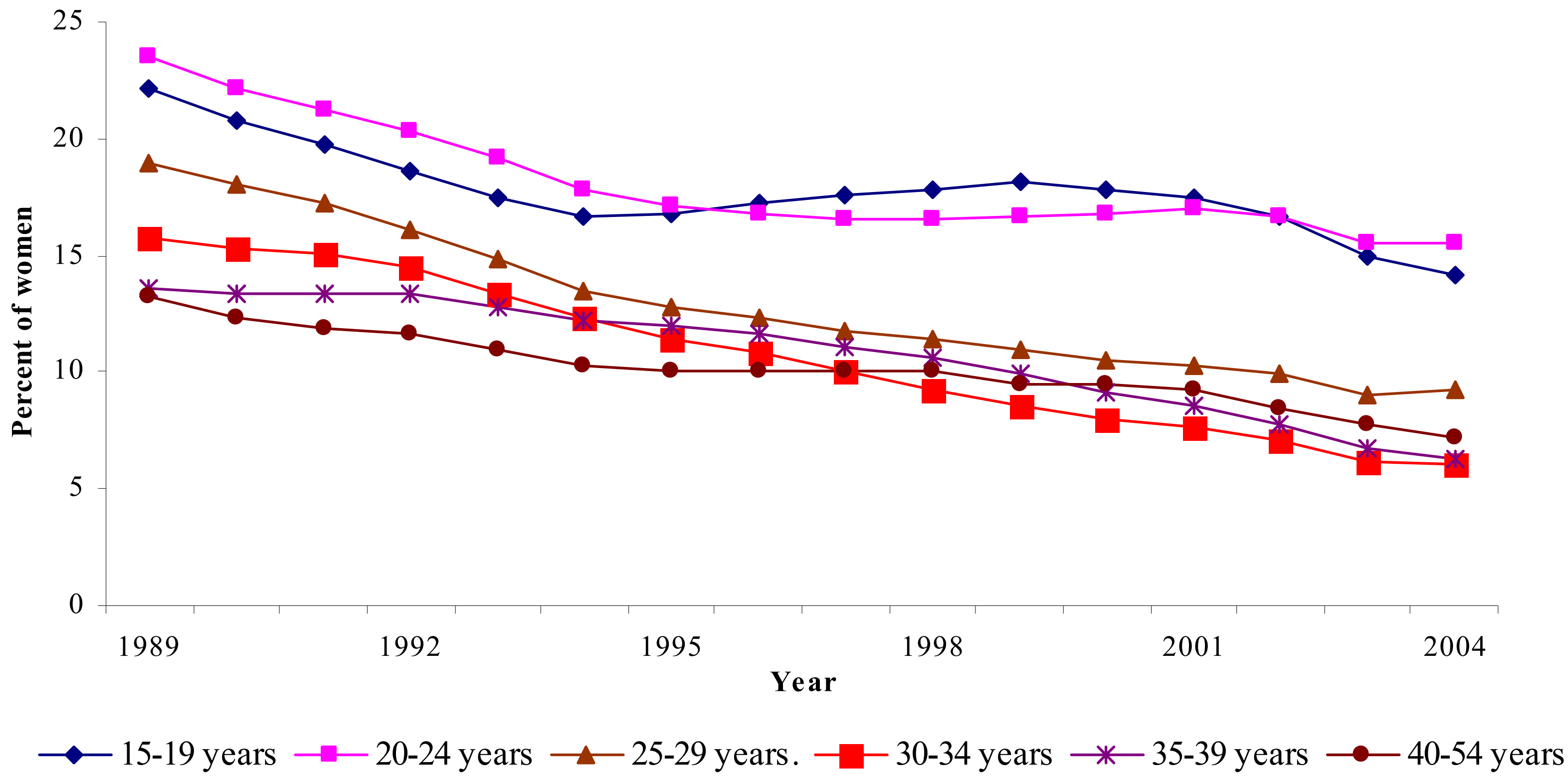
Data from National Center for Health Statistics: *Health, United States, 2006*

Figure 2. Prenatal Smoking by Education Level Among Mothers 20 Years or Older, 1989-2004



Data from National Center for Health Statistics: *Health, United States, 2006*

Figure 3. Prenatal Smoking in the United States by Age of Mother, 1989-2004



Data from National Center for Health Statistics: *Health, United States, 2006*

Figure 4. Smoking During Pregnancy by Race/Ethnicity: Eight PNSS States, 1995-2004

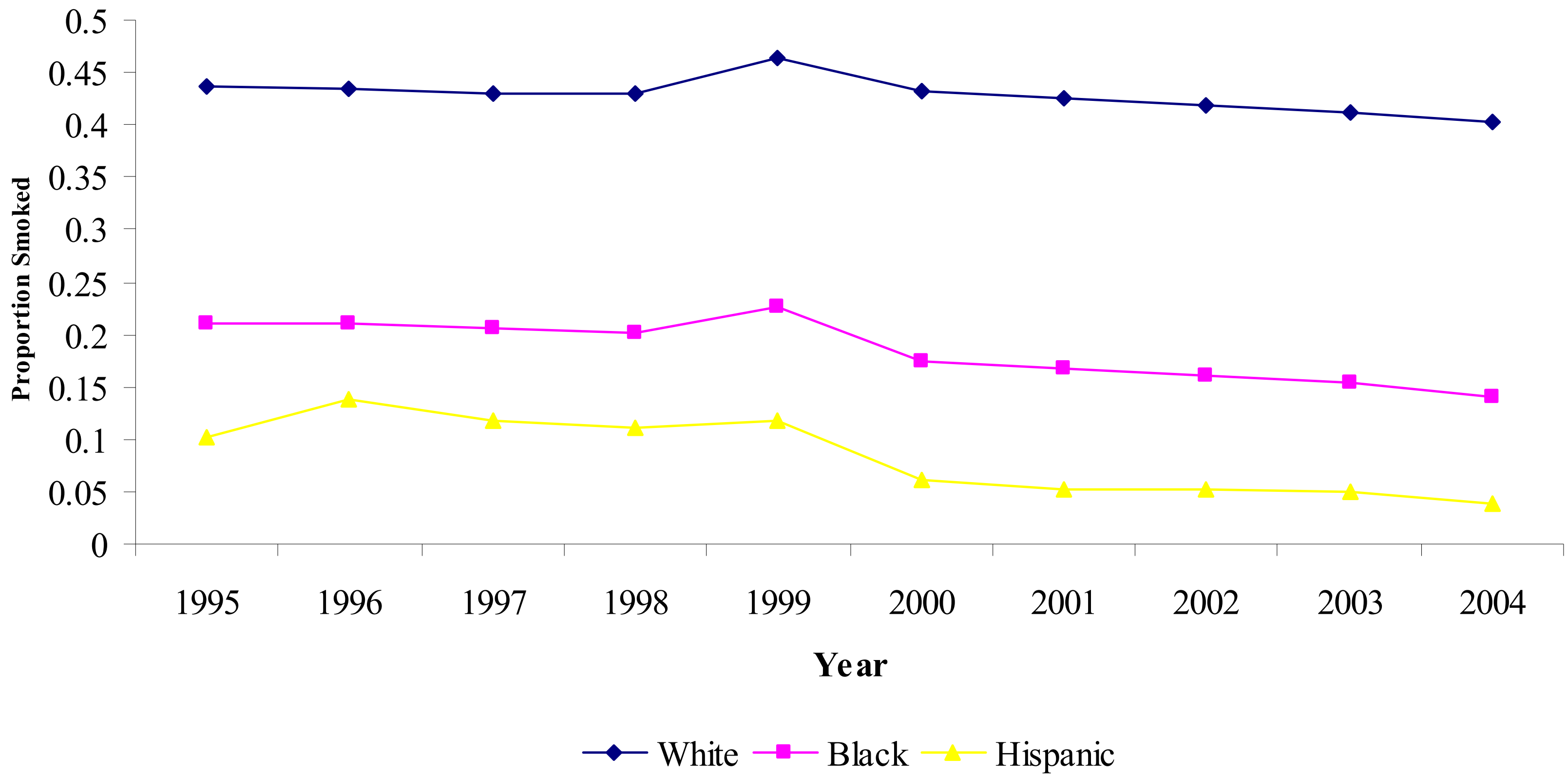


Figure 5. Smoking among Prenatal WIC Enrollees, by Weeks Pregnant When Enrolled in WIC

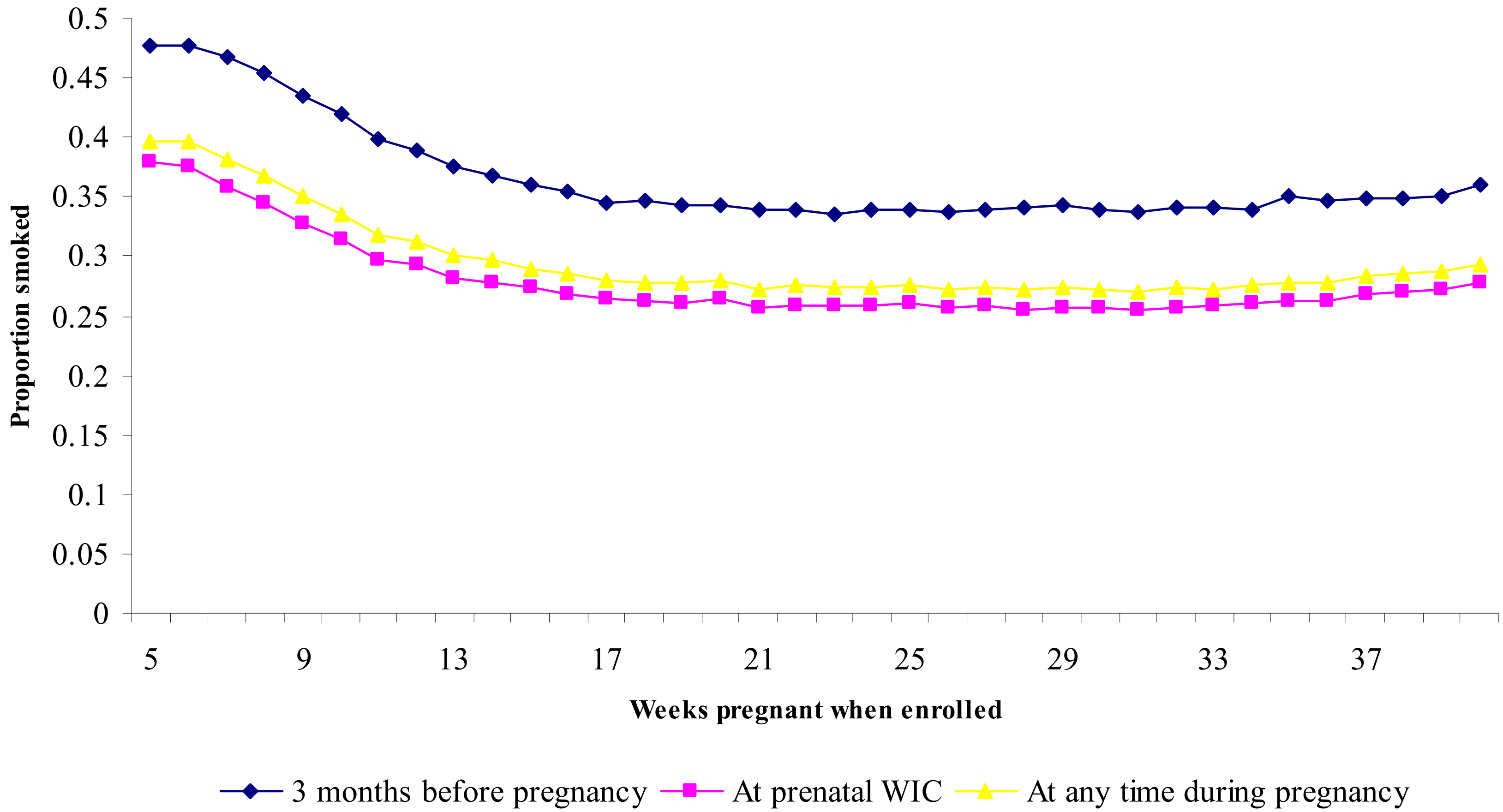


Figure 6. Smoking among Prenatal WIC Enrollees, by Weeks Pregnant When Enrolled in WIC: MI, MO, NC, OH, VA

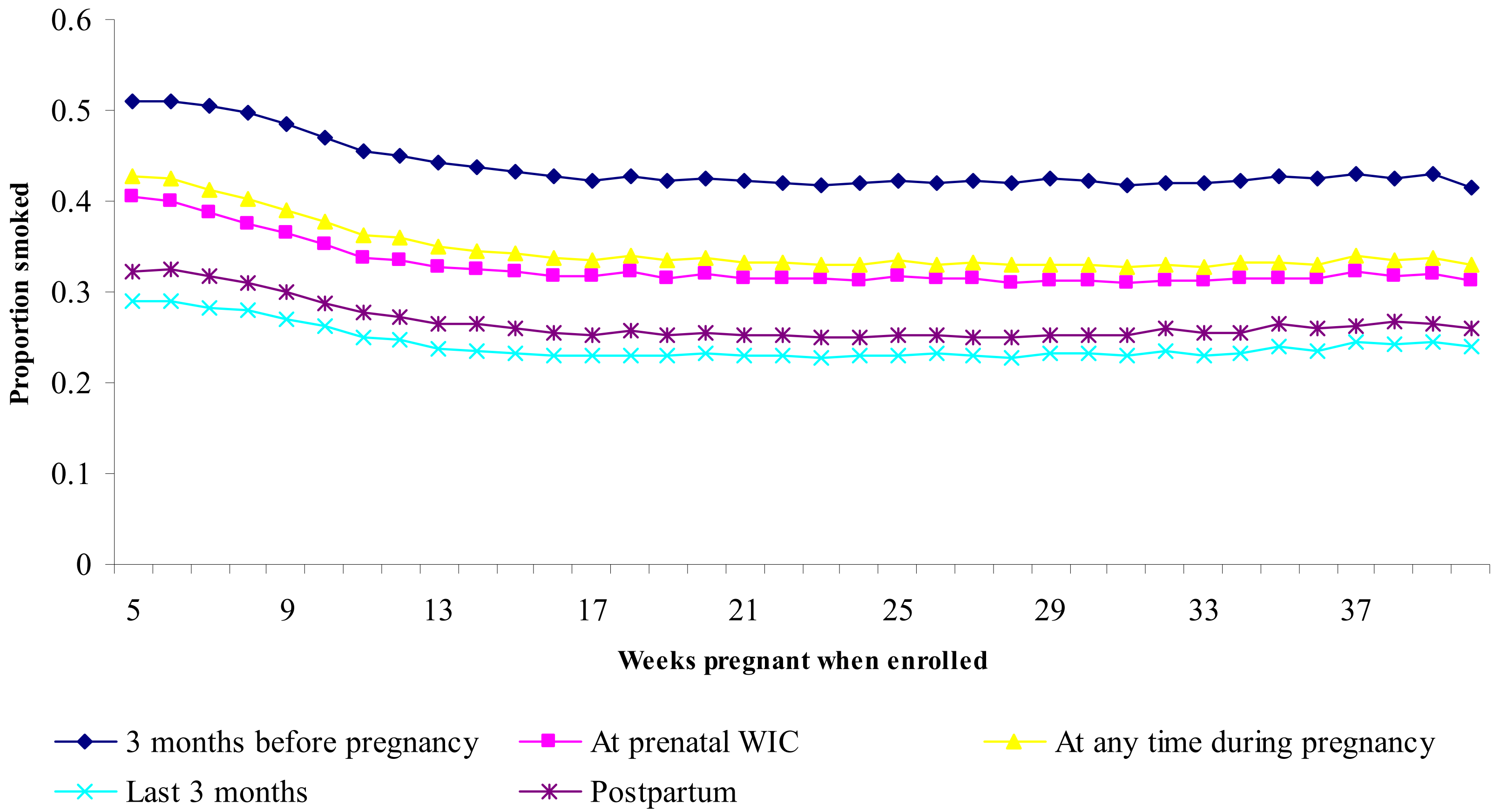


Figure 7. Mean Birth Weight by Pregravid Smoking Status of Mother: Prenatal WIC Enrollees, 1995-2004

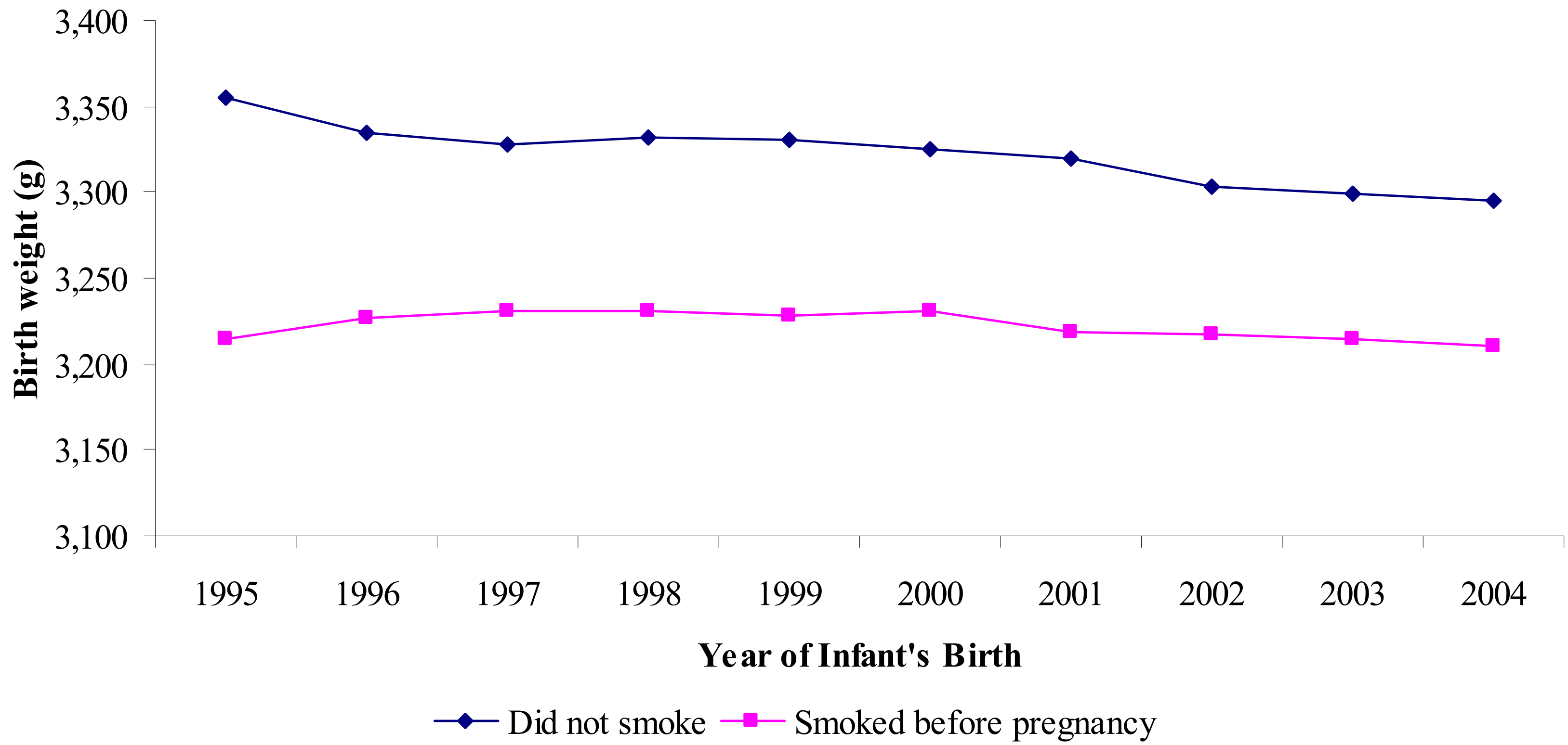


Figure 8. Mean LBW by Pregravid Smoking Status of Mother: Prenatal WIC Enrollees, 1995-2004

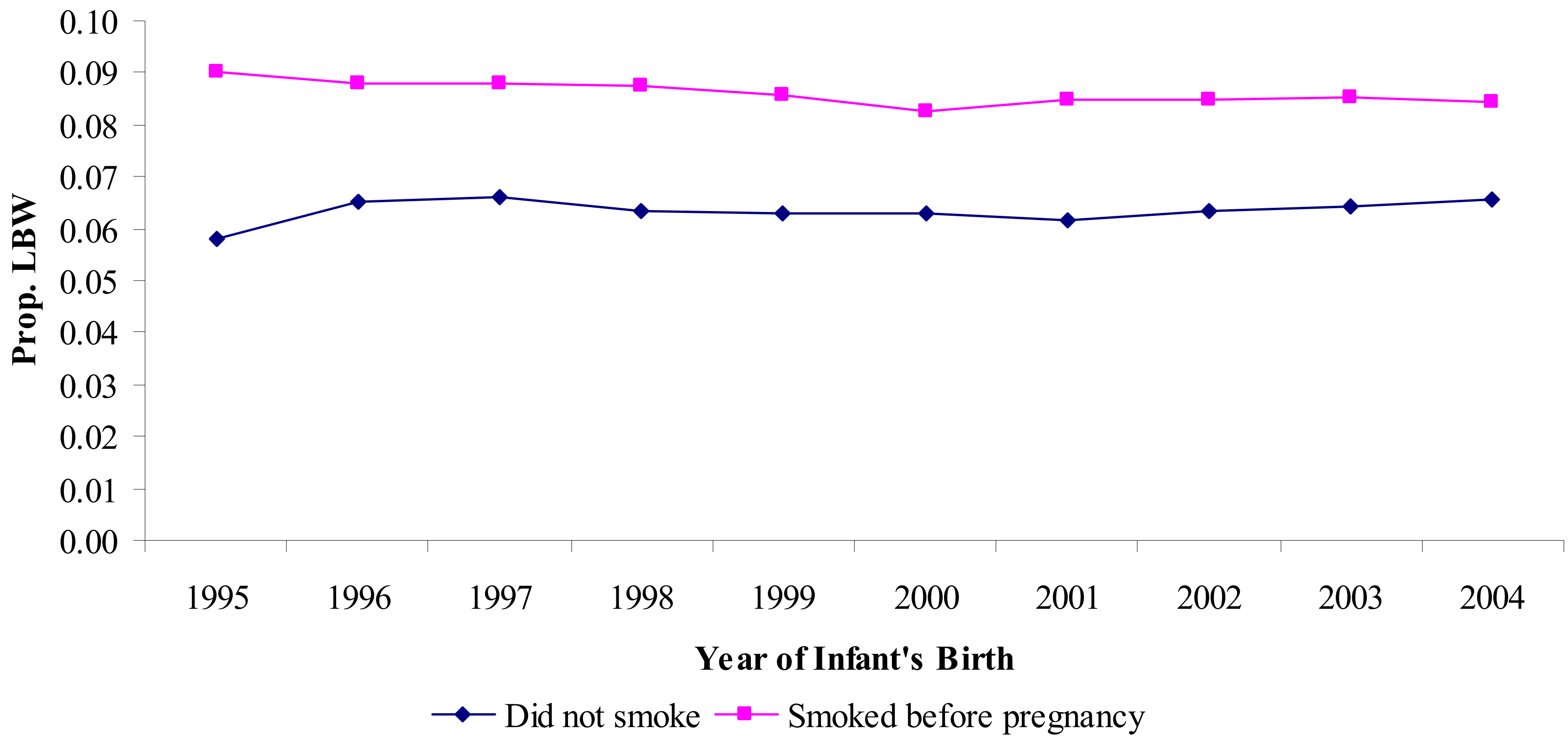


Figure 9. Mean SGA by Pregravid Smoking Status of Mother: Prenatal WIC Enrollees (FL, IN, MO, NC, NJ, OH), 1995-2004

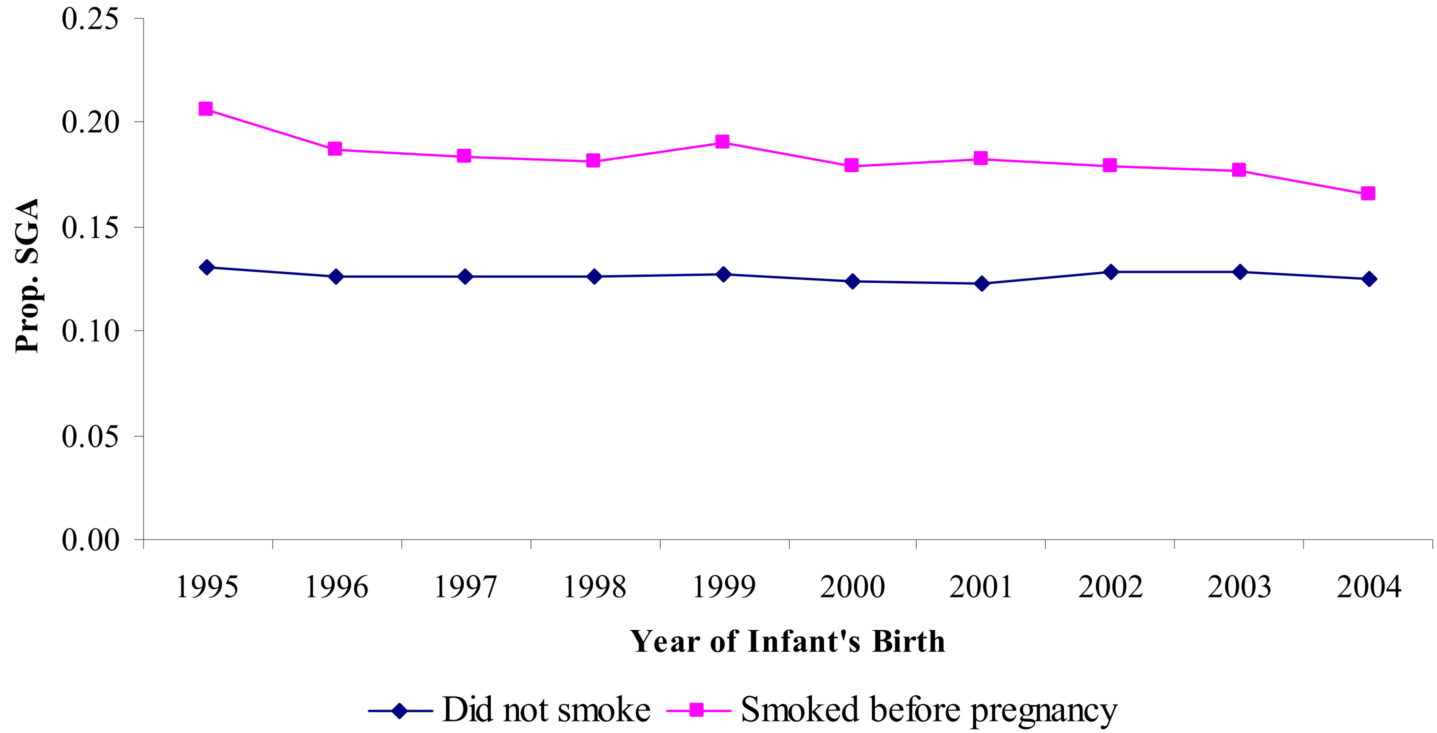


Figure 10. Mean Birth Weight by Smoking Status of Mother: Prenatal WIC Enrollees, 1995-2004

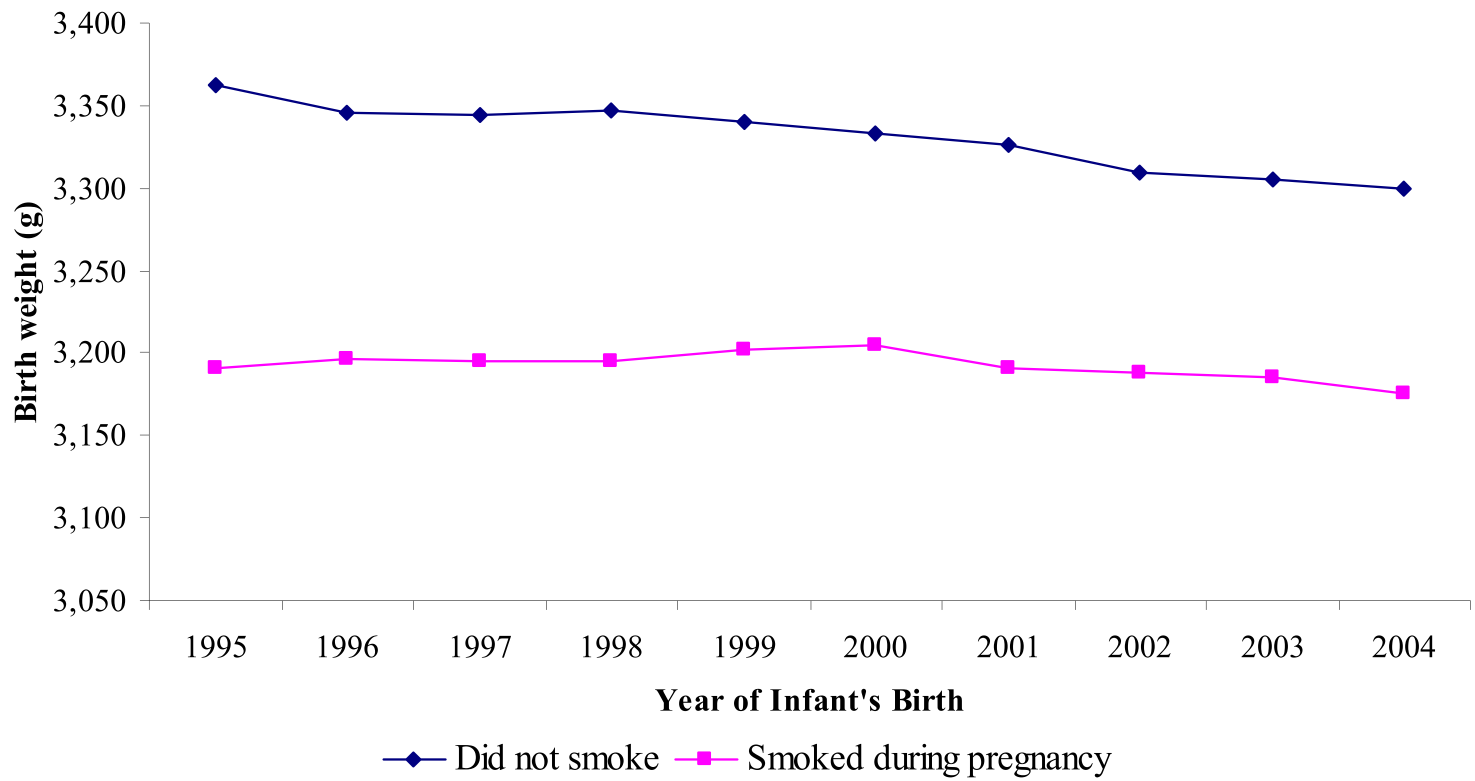


Figure 11. Mean Birth Weight, by Smoking Status of Mother: MI, MO, NC, OH, VA

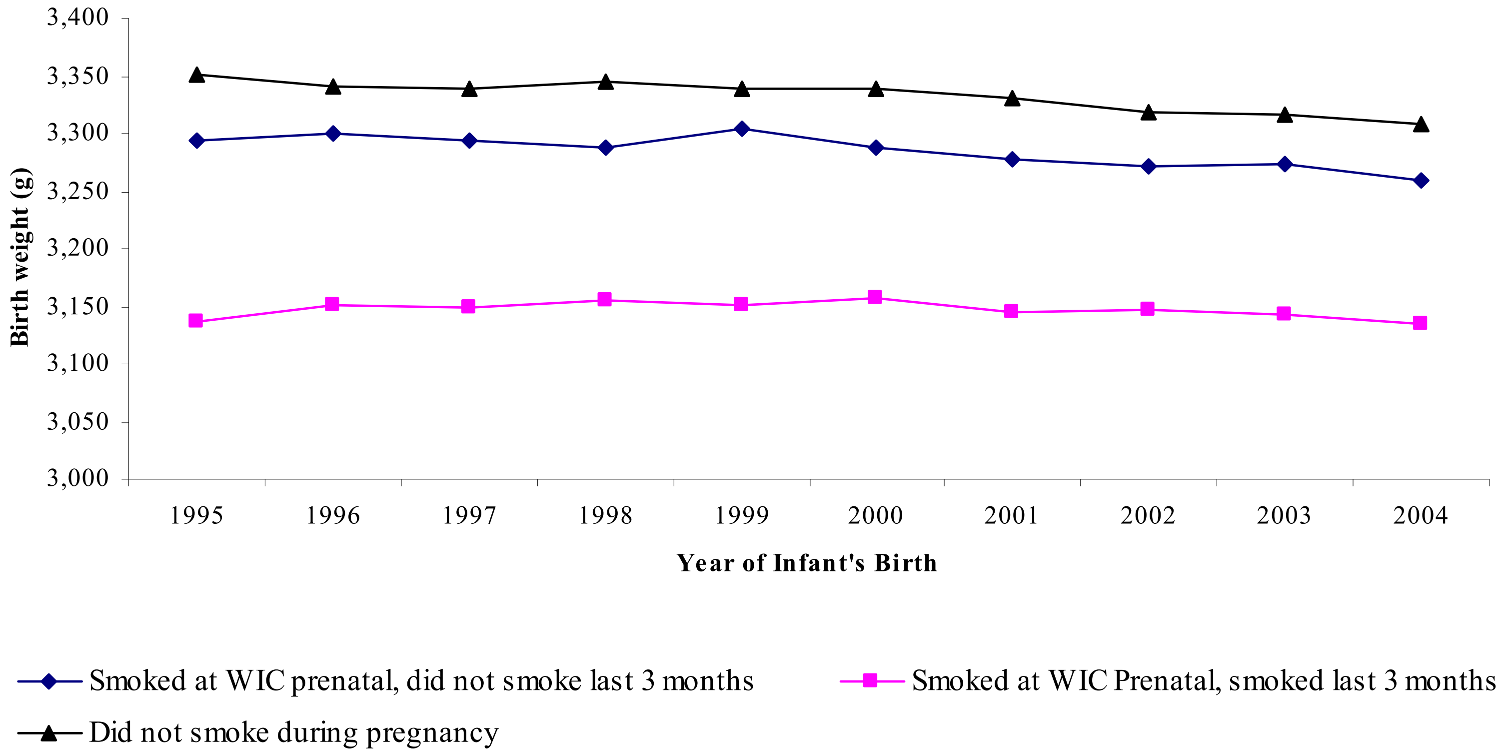


Figure 12. Mean LBW by Smoking Status of Mother: Prenatal WIC Enrollees, 1995-2004

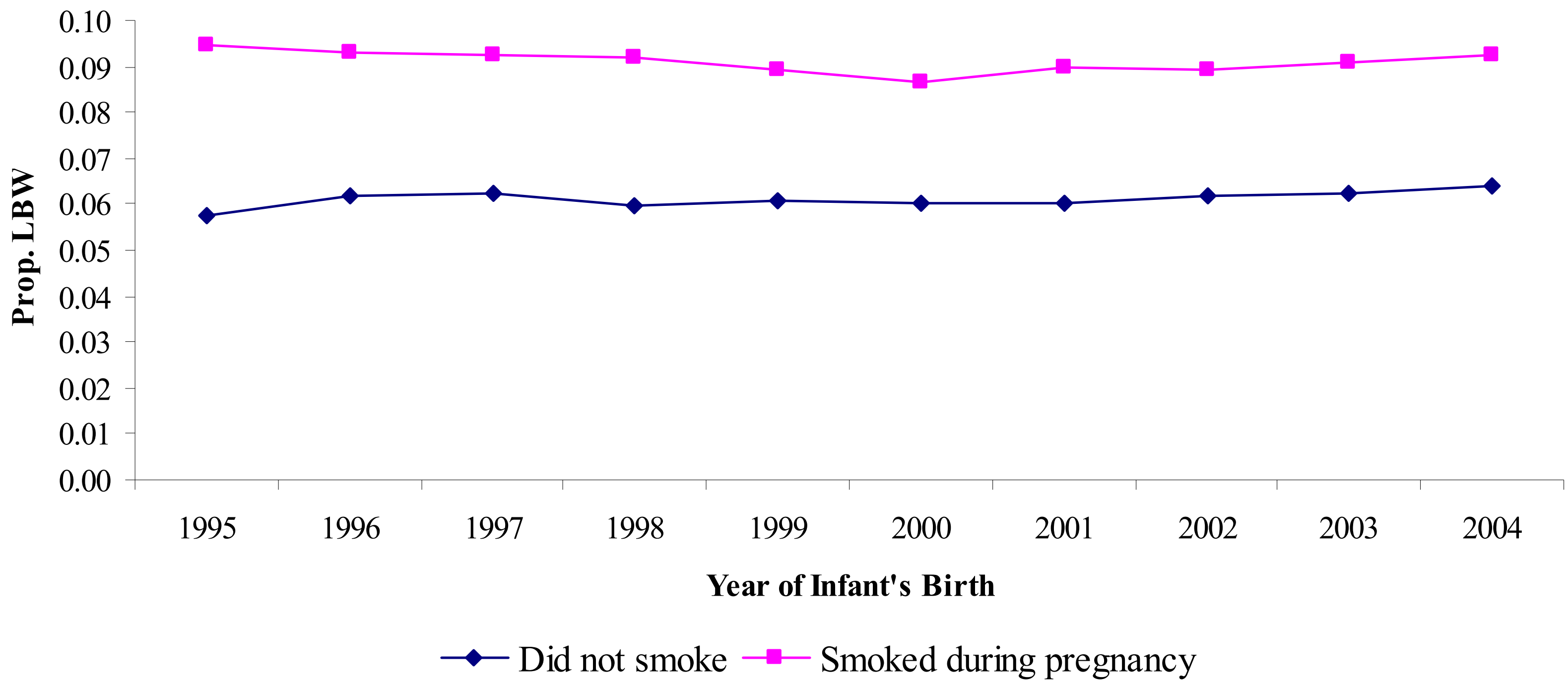


Figure 13. Mean LBW, by Smoking Status of Mother: MI, MO, NC, OH, VA

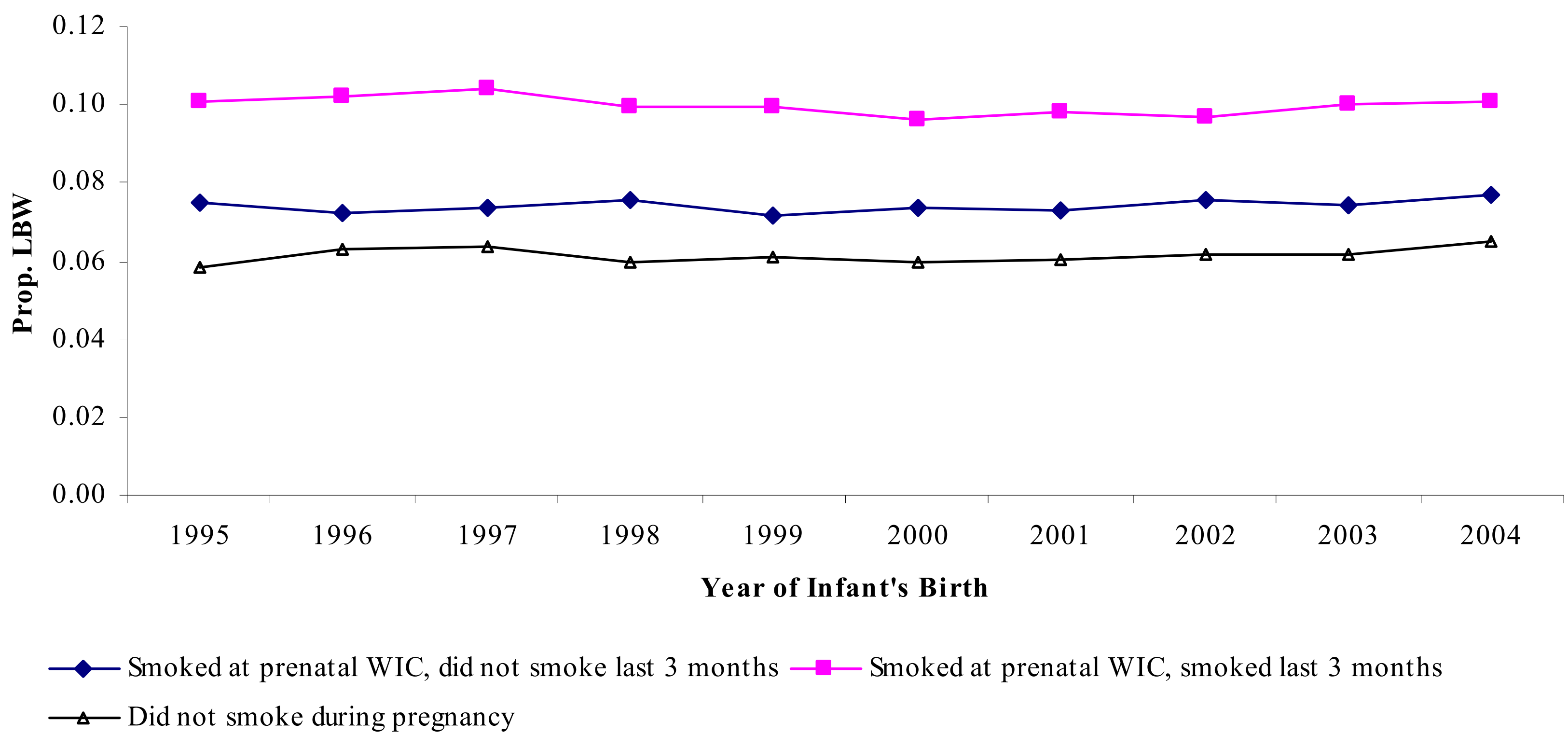


Figure 14. Mean SGA by Smoking Status of Mother: FL, IN, MO, NC, NJ, OH

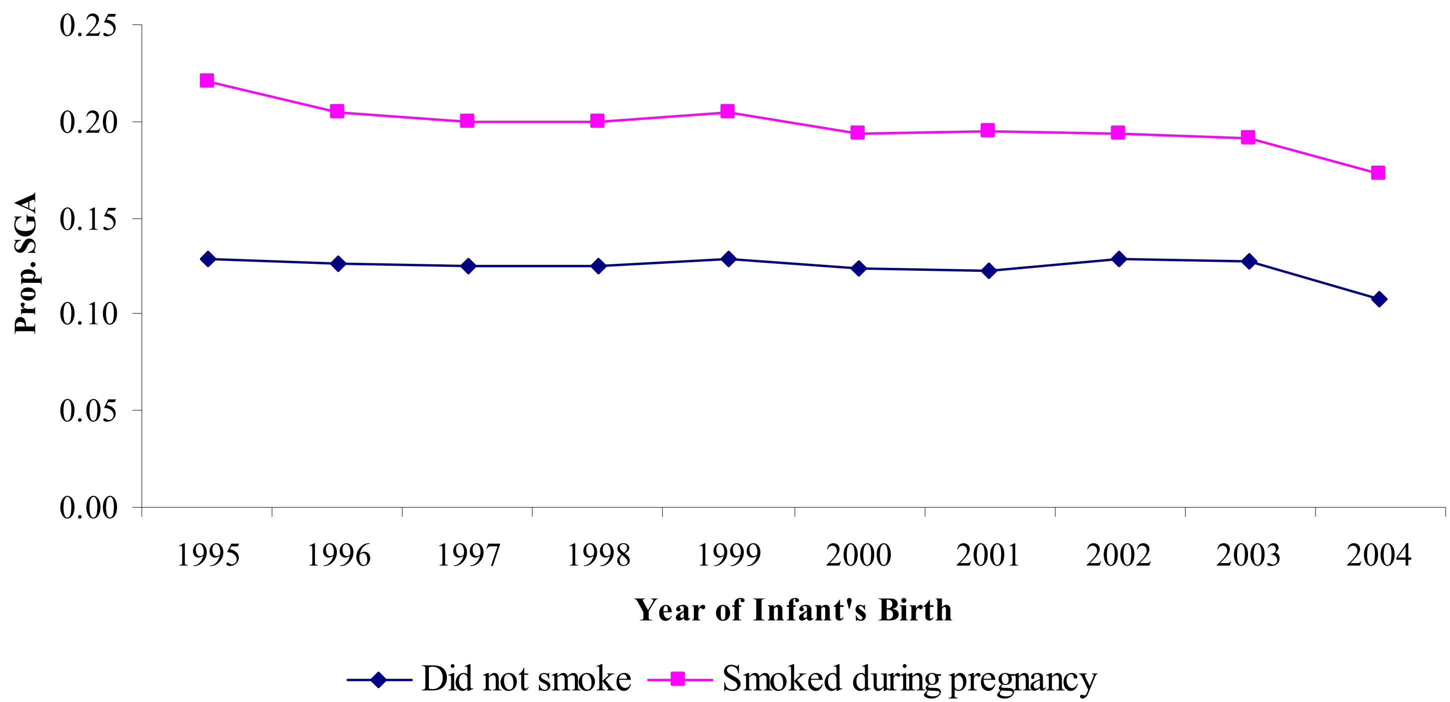


Figure 15. Mean SGA, by Smoking Status of Mother: MO, NC, OH

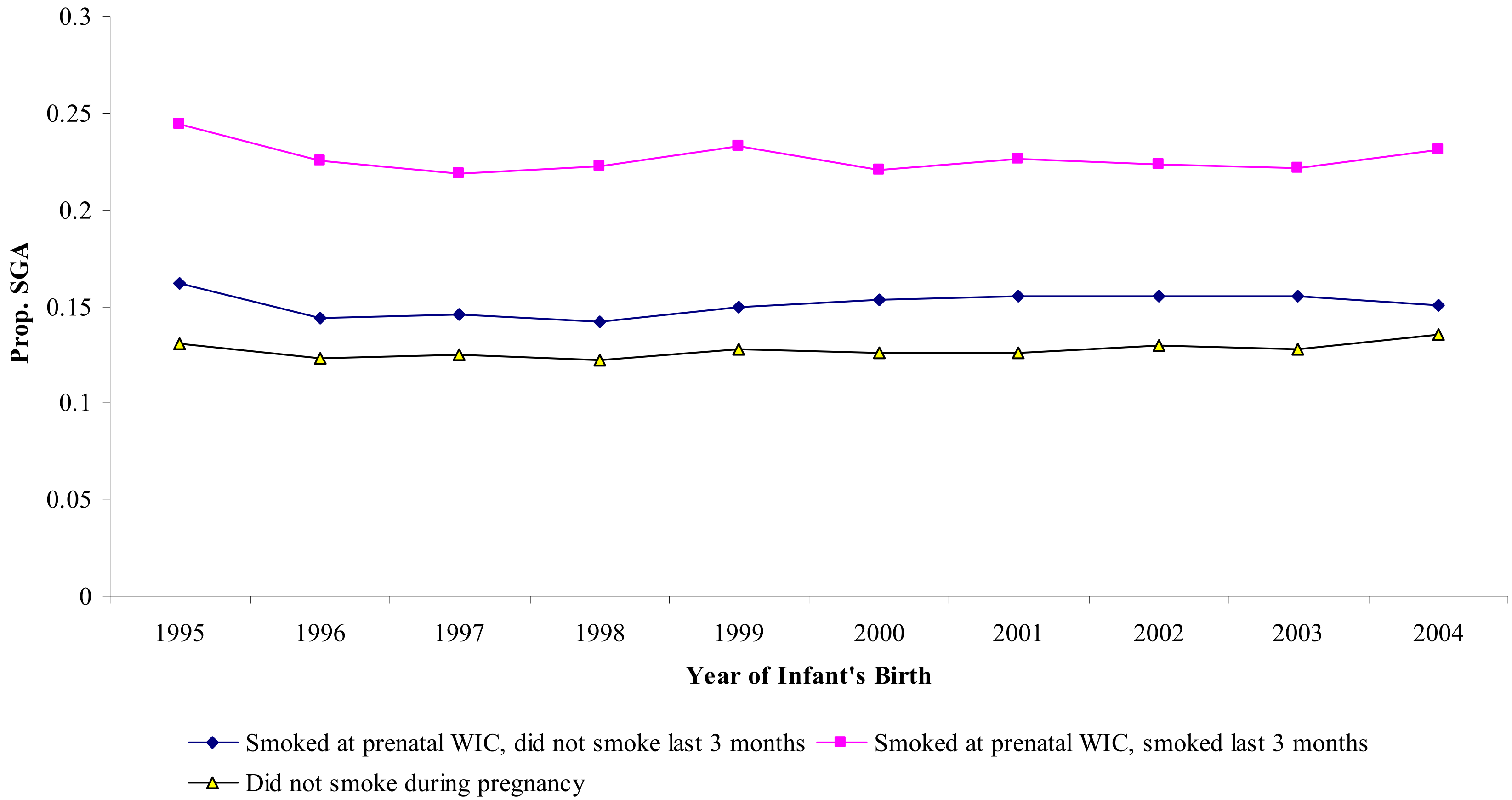
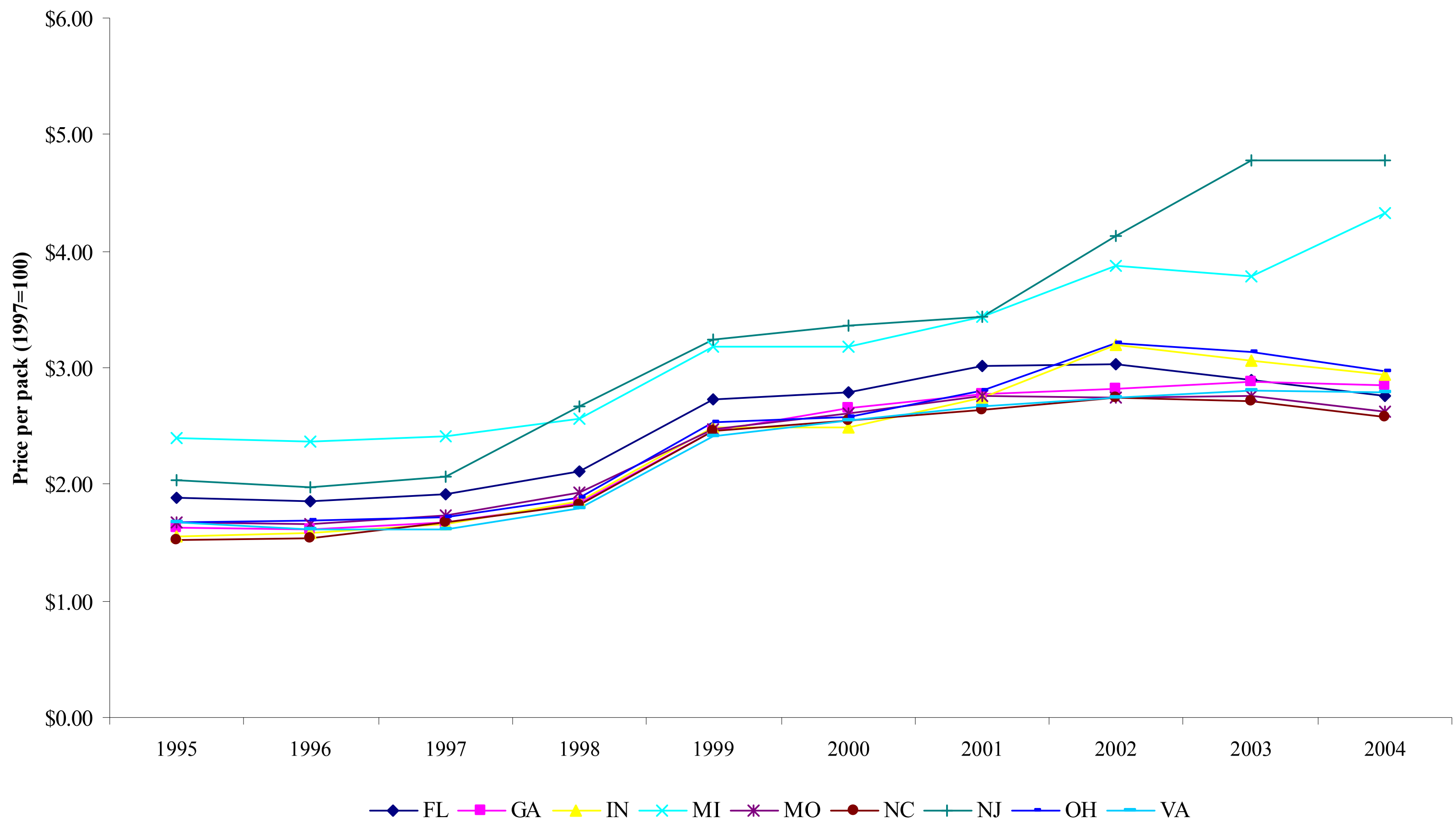


Figure 16. Real Cigarette Prices, 1995-2004



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