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The Effect of the 2009 WIC Revision on Maternal and Child Health: A Quasi-Experimental Study

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Abstract

BACKGROUND: The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is the largest U.S. nutrition program for low-income pregnant women. It was revised in 2009, with the goal of improving nutritional content of food packages, enhancing nutrition education, and strengthening breast feeding support. Few studies have assessed the effects of this revision on perinatal health.

OBJECTIVES: To investigate the impact of the revised WIC program on maternal and child health in a large, multi-state data set.

METHODS: We conducted a quasi-experimental difference-in-differences analysis, comparing the pre/post changes among WIC recipients to changes among non-recipients. We adjusted for key sociodemographic covariates in multivariable linear models. We used data from the Pregnancy Risk Assessment Monitoring System (PRAMS) for 18 states from 2004–2017.

RESULTS: The main analysis included 331,946 mother-infant dyads. WIC recipients were more likely to be younger, Black or Hispanic/Latina, unmarried, and of greater parity. The revised WIC program was associated with reduced likelihood of more-than-recommended GWG (−1.29% points, 95% CI −2.03, −0.56) and increased likelihood of ever breast fed (1.18% points, 05% CI 0.28, 2.08). We also identified heterogeneous effects on GWG, with more pronounced associations among women 35 and older. There were no associations with fetal growth.

CONCLUSIONS: The revised WIC program was associated with improvements in women's gestational weight gain and infant breast feeding.

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Conflicts of Interest: None

Keywords

PRAMS; Quasi-Experimental Studies; WIC Program; Maternal Health; Infant Health; Nutrition During Pregnancy; Policy Analysis; United States

BACKGROUND

Maternal nutrition can impact the short-term and long-term health of both women and their children. For women, excessive or insufficient gestational weight gain (GWG) due to poor nutrition can result in complications during delivery, postpartum weight retention, and increased risk of diabetes.[1,2] For infants, poor maternal nutrition can result in epigenetic changes and alterations in fetal metabolism that increase the risk of future chronic disease.[3–7] Moreover, disparities in perinatal health exist among U.S. women. Black and Hispanic women are more likely to have inadequate weight gain during pregnancy, which may explain their higher risk of preterm and small for gestational age births.[8,9] Women who are unmarried or with lower educational attainment are more likely to face economic disadvantage, increasing the risk of having a low birthweight infant.[10] This intergenerational transmission of inequity may contribute to the persistent health disparities in the U.S.[10] Efforts to ensure adequate maternal nutrition are key to supporting the health of both women and children.

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is among the most important nutrition policies for low-income families in the U.S. WIC is a federal program that offers standardized food packages, nutrition education, breast feeding support, and referrals to health and social services for low-income pregnant and postpartum women and children younger than 5 years old.[11] Although only 50% of eligible pregnant women and 62% of eligible postpartum women receive benefits,[12] WIC still serves more than a quarter of pregnant and postpartum women.[13] Approximately 45% of WIC recipients are Hispanic, 20% are Black, and two-thirds have a high school education or less.[14] Research shows that WIC receipt results in improved birth outcomes with the greatest impacts among women who are more likely to face economic disadvantage (e.g. women with a high school education or less).[15–17]

To further improve maternal and child health, the U.S. Department of Agriculture enacted major revisions to the WIC program in 2009, the first major change since it was implemented in 1974.[18] The revised food package aimed to provide more fresh fruits and vegetables, whole grain bread, and low fat milk, with the goal of reducing intake of saturated fat, cholesterol, total fat, and sodium.[18] The revised program also offered improved nutrition education and breast feeding support. Prior studies have found that the revised WIC program was associated with increased availability of healthy foods at neighborhood stores[19,20] and increased household expenditures on healthy foods.[21–24] Research on health outcomes has been limited, with a handful of studies finding that the revised WIC program improved maternal and child dietary quality,[25–28] and improved GWG, infant birth weight, and measures of child growth and development.[29–31] Select studies involved rigorous, quasi-experimental designs, but used small samples or narrow geographies. Further research is

needed to evaluate the effects of the revised WIC program in a more generalized sample to inform national policymaking.

The present study evaluated the revised WIC program using data from over 300,000 births in 18 states. We conducted a quasi-experimental difference-in-differences (DID) analysis to estimate the associations of the revised WIC program with several measures of maternal and child health. We hypothesized that receipt of the revised WIC program would result in improved health outcomes.

METHODS

This study used data from the 2004–2017 waves of the Pregnancy Risk Assessment Monitoring System (PRAMS), a surveillance project of the U.S. Centers for Disease Control and Prevention whose methodology has been described previously.[32] Briefly, PRAMS connects data from a representative sample of birth certificate records to women's survey responses on behaviors, attitudes, and experiences before, during, and shortly after pregnancy. Roughly 1,300–3,400 women are surveyed in each location each year.[32]

SAMPLE SELECTION

We excluded data prior to 2004 due to differences in how birth certificate data were collected in earlier years. The most recent PRAMS data available to our team included data through 2017. While states and territories participating in PRAMS represent approximately 81% of all U.S. live births, PRAMS data are only released in a given year for those localities that have adequate response rates (55%−70%, varying by year).[32,33] We limited the main analysis to 18 states during the study period for which data were missing in no more than 3 years (eTable 1). We restricted the sample to live-born singleton infants with a gestational age of 20–44 weeks at delivery (Figure 1). The final sample size was 331,946.

EXPOSURE

The main exposure variable was whether a woman participated in the revised WIC program. Both the PRAMS survey and birth certificate data asked whether the woman received WIC benefits during her most recent pregnancy. For this analysis, we combined WIC status assessed by the PRAMS survey and linked birth certificate data. State-level implementation of WIC revisions was staggered throughout 2009; occurring as early as January 2009 and as late as November 2009.[21] Among WIC recipients, we considered a women to have benefited from the revised program is she gave birth after the implementation of the revision in her state.

A woman whose pregnancy included 2009 was classified as having received the revised WIC program if at least half of her pregnancy occurred after the program revision.

OUTCOMES

We selected maternal and infant outcomes that could be affected by the woman's receipt of the revised WIC program and for which PRAMS data were consistently collected across multiple states and years. Maternal outcomes included whether the woman was diagnosed

as having gestational diabetes mellitus (GDM) and whether her gestational weight gain (GWG) was less-than, more-than, or within the recommended range according to the 1990 guidelines from the Institute of Medicine (IOM).[34] We assessed GDM using combined data from the infant's birth certificate and the PRAMS questionnaire. GWG in pounds was obtained from the infant's birth certificate.

Infant outcomes obtained through birth certificate data included gestational age (continuous), preterm birth (<37 weeks gestation), and fetal growth categories: appropriate for gestational age (AGA), small for gestational age (SGA), and large for gestational age (LGA). Infant outcomes assessed through the PRAMS questionnaire included extended hospitalization after birth (≥6 days), and ever breast fed.

COVARIATES

We adjusted models for women's age, race and ethnicity, education, marital status, household income (>$50,000 in 12 months prior to delivery), receipt of Medicaid during pregnancy, parity, and fixed effects (i.e., indicator variables) for state and child's birth year. State fixed effects accounted for time-invariant characteristics of states that may have affected the implementation of the WIC revision and outcomes of interest. Year fixed effects accounted for time-varying characteristics that may impact WIC uptake and the outcomes of interest (i.e., secular or underlying trends due to other external causes). While PRAMS collects granular data on race and ethnicity, we aggregated this variable into larger categories (non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, Hispanic/Latina, and non-Hispanic other) to mitigate issues arising from small sample sizes in select categories. We acknowledge that individual experiences within each group are heterogenous and that these categories may not adequately capture race and ethnicity.

STATISTICAL ANALYSES

We estimated the association of the revised WIC program with each outcome using difference-in-differences (DID) analysis. DID is a quasi-experimental technique suited to examining the effects of policy changes while accounting for secular trends.[35,36] We took advantage of the fact that the 2009 WIC revisions were unlikely to be associated with individual maternal or infant characteristics, resulting in a natural experiment. In effect, DID compared outcomes among WIC recipients before and after revisions took place, while accounting for secular trends in outcomes by "differencing out" pre/post changes observed among a control group of non-recipients.

DID analyses require that several assumptions be met (see Supplement). Practically speaking, DID analysis involves multivariable linear regressions, including an interaction term between WIC status and pre/post implementation of the revised WIC program, and adjusting for the covariates above. Robust standard errors were clustered by state to account for correlated observations.

MISSING DATA

Percent missingness among covariates ranged from 0% (for age) to 8% (for household income). We used multiple imputation using chained equations to impute missing covariates (see Supplement).

SUBGROUP ANALYSES

To test for heterogeneity in response to the WIC revision, we conducted subgroup analyses by age, education, race and ethnicity, and marital status. First, we conducted stratified analyses to produce estimates of the primary coefficient for each group. Second, we conducted regressions including an interaction term between each maternal characteristic and the primary exposure variable to determine if stratum-specific coefficients were statistically different from those for the reference group. Previous literature suggests that the impact of the 2009 WIC revision may differ by age, education, race and ethnicity, and marital status, and WIC receipt has been shown to have different impacts by women's educational attainment. These analyses therefore examine the potential differential impacts of WIC among various subgroups facing marginalization and/or socioeconomic hardship.

SENSITIVITY ANALYSES

We conducted several sensitivity analyses to assess the robustness of results. First, we restricted the sample to observations in 2007–2017 (n = 313,294), which allowed us to include 6 more states that had substantial missingness for 2004–2006. Second, we restricted the sample to women whose pregnancies did not overlap with the date that the WIC revision was implemented in their state of residence (n = 302,928), enabling us to evaluate women who were exposed to the revised WIC program throughout their entire pregnancy. This reduces misclassification due to women potentially being only partially exposed during their pregnancies. Third, we restricted the sample to women whose household income was less than $50,000 (n = 192,294), since higher-income women might not represent an appropriate control group for WIC recipients. Fourth, we restricted the sample to women with no more than 12 years of formal education (n = 148,200) since more educated women might also not represent an appropriate control group. Fifth, we further adjusted our main analytic models to account for possible confounding by other state-level time-varying safety net policies: state EITC (Earned Income Tax Credit) rate, state food stamp/SNAP (Supplemental Nutrition Assistance Program) caseload, state AFDC (Aid to Families with Dependent Children)/TANF (Temporary Assistance for Needy Families) caseload, gross state product per capita, state unemployment rate, and state expansion of Medicaid.

ETHICS APPROVAL

Ethical approval for this study was provided by the Institutional Review Board of the senior author's university (protocol #18–26719).

RESULTS

The final sample included 331,946 mother-infant dyads. While WIC recipients differed from non-recipients in several respects, DID assumes that the trends (i.e., slopes), not the levels, of outcomes are similar between the two groups. For example, WIC recipients were more

likely to be younger, Black or Hispanic/Latina, unmarried, and of greater parity (Table 1). Maternal health was similar for WIC recipients and non-recipients, except for a lower percentage of within-recommended GWG among WIC recipients. Infant health was similar between WIC recipients and non-recipients, except for fewer breast-fed infants among WIC recipients (Table 2).

DIFFERENCE-IN-DIFFERENCES MODEL ASSUMPTIONS

In qualitative and quantitative evaluations, most outcomes demonstrated parallel trends during the pre-revision period, meeting a basic assumption of DID analysis (eFigure 1, eFigure 2, eTable 2). The exceptions were GDM and LGA, and we subsequently excluded these from further analyses since this implied that non-recipients were not an appropriate control group for recipients for these outcomes.

When we examined the parallel trends graphs for sensitivity analyses that restricted the sample by income or educational attainment, the trends during the pre-revision period were no longer parallel among WIC recipients and non-recipients. It may be that low-income and low-education non-recipients represent a fundamentally different group of women due to unobserved characteristics (e.g., immigration status). Consequently, we conducted our main analysis without restrictions on income or education.

We observed compositional changes by age, education, and parity among WIC recipients and non-recipients over time. We adjusted for these covariates in our regression models, although it may be that there are other unmeasured characteristics that differ between these two groups.

EFFECTS OF THE REVISED WIC PROGRAM ON MATERNAL HEALTH

The revised WIC program was associated with reduced likelihood of more-than-recommended GWG by −1.29% points (95% confidence interval [CI] −2.03, −0.56) (Table 3). In sensitivity analyses with the shortened pre-revision period, excluding pregnancies that overlapped with the WIC revision, and further adjustment for time-varying state-level policies, results for more-than-recommended GWG were similar to the main analysis. A sensitivity analysis with the shortened pre-revision period, but not the main analysis, also identified that the revised WIC program was associated with increased likelihood of less-than-recommended GWG.

EFFECTS OF THE REVISED WIC PROGRAM ON INFANT HEALTH

The revised WIC program was associated with an increased likelihood of ever breast fed by 1.18% points (95% CI 0.28, 2.08) (Table 3). In the sensitivity analyses excluding pregnancies that overlapped with the WIC revision and further adjustment for time-varying state-level policies, but not for that with the shortened pre-revision period, these results were similar to the main analyses.

SUBGROUP EFFECTS

There were differences in the estimated associations of the revised WIC program with select outcomes by age, education, and marital status. The reductions in more-than-recommended

GWG associated with the revised WIC program were more pronounced in older women relative to younger women (eTable 3A) and among married women relative to unmarried women (eTable 3D). The revised WIC program was also associated with increased likelihood of within-recommended GWG only among women ages 35 and older. We also found that the revised WIC program was associated with increased likelihood of ever breast fed among women with more than 12 years of education (eTable 3B). We found no differences in the association of the revised WIC program with health outcomes by race and ethnicity (eTable 3C).

COMMENT

PRINCIPAL FINDINGS

We found a reduction in more-than-recommended GWG of 1.29% points (roughly 3.0% from baseline) and an increase in ever breast fed of 1.18% points (roughly 1.6% from baseline) among WIC recipients after the implementation of the revised WIC program. These improvements were robust in sensitivity analyses, and are small effect sizes at the individual level but would result in meaningful changes at the population level.[37] When assessing for heterogeneous effects of the WIC revision, we found that improvements in GWG were more pronounced among women over 35.

STRENGTHS OF THE STUDY

This study has several strengths. It employed a natural experiment to rigorously estimate the association of the revised WIC program with maternal and infant health, adding to the evidence that the revisions improved several dimensions of health for women and children. This study expands on previous research to examine the effects of the WIC revision in a multi-state sample, enhancing generalizability relative to studies conducted in a single location.

LIMITATIONS OF THE DATA

While our study population includes participants from 18 states, we were unable to include data from all states because of low response rates and missing data in select years of PRAMS. Furthermore, WIC is intended to be standardized nationwide, but program administration and the foods available may vary by state. We accounted for this limitation by applying state fixed effects and clustering standard errors by state. We also did not have information on the timing of WIC enrollment during pregnancy, which may lead to misclassification error, although the sensitivity analysis that excluded women whose pregnancies overlapped with the revision roll-out was similar to the main analysis. While we assessed parallel trends both quantitatively and graphically, we recognize that failure to reject the null hypothesis of non-parallel trends does not confirm the existence of parallel trends.[38] Additionally, DID analysis requires that there be no other exposures that may differentially influence outcomes between the treatment and control groups over the study period. For example, the Great Recession of 2008–2009 occurred during a similar time period; however, other work posits that adverse health effects of the recession accrued disproportionately to individuals of lower socioeconomic status, which would bias our results towards the null.[39] Our findings actually show improvement in select outcomes

among WIC recipients, so that the Great Recession may have moderated the observed effect of the revised WIC program. Similarly, IOM guidelines for recommended GWG changed in 2009, with obese women encouraged to gain less weight relative to underweight, normal weight, and overweight women. Since WIC recipients are more likely to be obese, this might bias our results. However, a separate study has found that the 2009 IOM guidelines did not affect WIC recipients and non-recipients differently, so this is unlikely to be the case.[40] Lastly, while we adjusted for a robust set of individual- and state-level variables to account for possible confounding, as with any DID analysis the results may be subject to residual confounding by unmeasured characteristics.

INTERPRETATION

Our findings on GWG are consistent with prior work examining the effects of the WIC revision in California.[29] This may be attributable to the switch to more nutritious foods such as low-fat milk instead of whole milk and whole grains instead of white bread (the latter having a higher glycemic index).[41] Excessive GWG is correlated with increased likelihood of future obesity and chronic disease for mothers and children, and future studies can examine whether the effects persist in the long term.[42,43] Subgroup analyses also suggested that older women had more pronounced improvements in GWG. Future studies are needed to evaluate possible reasons for this finding, such as the possibility that older women more fully took advantage of the program benefits. We found mixed literature in different target populations on the association of age and more-than-recommended GWG.[44,45] Meanwhile, although maternal nutrition is a key predictor of gestational diabetes,[46] we were unable to evaluate the effects of the revised WIC program for this outcome because it did not meet the parallel trends assumption for DID analysis.

Our finding on ever breast feeding mirrors the results of a smaller study that concluded the 2009 WIC revision eliminated the disparity in ever breast feeding between WIC-eligible participating and non-participating children.[47] WIC offers distinct food packages to mothers and infants based on breast feeding status (e.g. full breast feeding versus formula feeding), and the revised WIC program sought to offer strong incentives to promote full breast feeding.[48] For example, mothers who were fully breast feeding received a greater quantity and variety of food,[49] and mothers who were partially breast feeding received no more than 45% of the maximum formula amount.[48] WIC also offers breast feeding counseling and support as core tenets of the program.[48] Our finding suggests that these changes were modestly successful in improving breast feeding among WIC recipients. We were unable to rule out the null hypothesis that there was no association of the revised WIC program with other infant outcomes. While prior work found that the revised WIC program is associated with improvements in preterm birth and low birthweight,[29] this study was conducted in California using earlier years of data, and findings may not be generalizable to other states or more recent years. It may be that effects on downstream infant outcomes were more modest than effects on women's health, given that the changes to the content of the WIC package were modest.

CONCLUSIONS

WIC serves more than a quarter of pregnant and postpartum women in the U.S., making it among the largest safety net programs for vulnerable families. Using a large, multi-state data set, we found that revisions to WIC in 2009 that enhanced nutrition support led to improvements in GWG and increases in breast feeding among WIC recipients. More recently in 2021, the WIC program was further expanded with even larger fruit and vegetable benefits,[50] and these policy changes should be evaluated in light of the present study. Other related state and community interventions that address maternal nutrition may also improve perinatal and child nutrition among vulnerable populations. Future work should continue to examine the downstream health impacts of the WIC revision in later life for women and children, and the effects of interventions on more upstream determinants like poverty and housing.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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SYNOPSIS

Study question:

To what extent did the 2009 revision to WIC—one of the largest safety net programs for low-income U.S. families—influence selected maternal and infant health outcomes?

What's already known:

Prior work, primarily done in small or geographically restricted samples, found that the 2009 WIC revision improved maternal nutrition, infant birth weight, and breast feeding.

What this study adds:

This study is among the first to assess the impacts of the WIC revision in a large multi-state sample of mother and infant dyads, providing more generalizable evidence to inform policymaking and program development. The revised WIC program was associated with improvements in gestational weight gain and ever breast feeding, strengthening the evidence for programs to provide nutrition and breastfeeding support to low-income women.

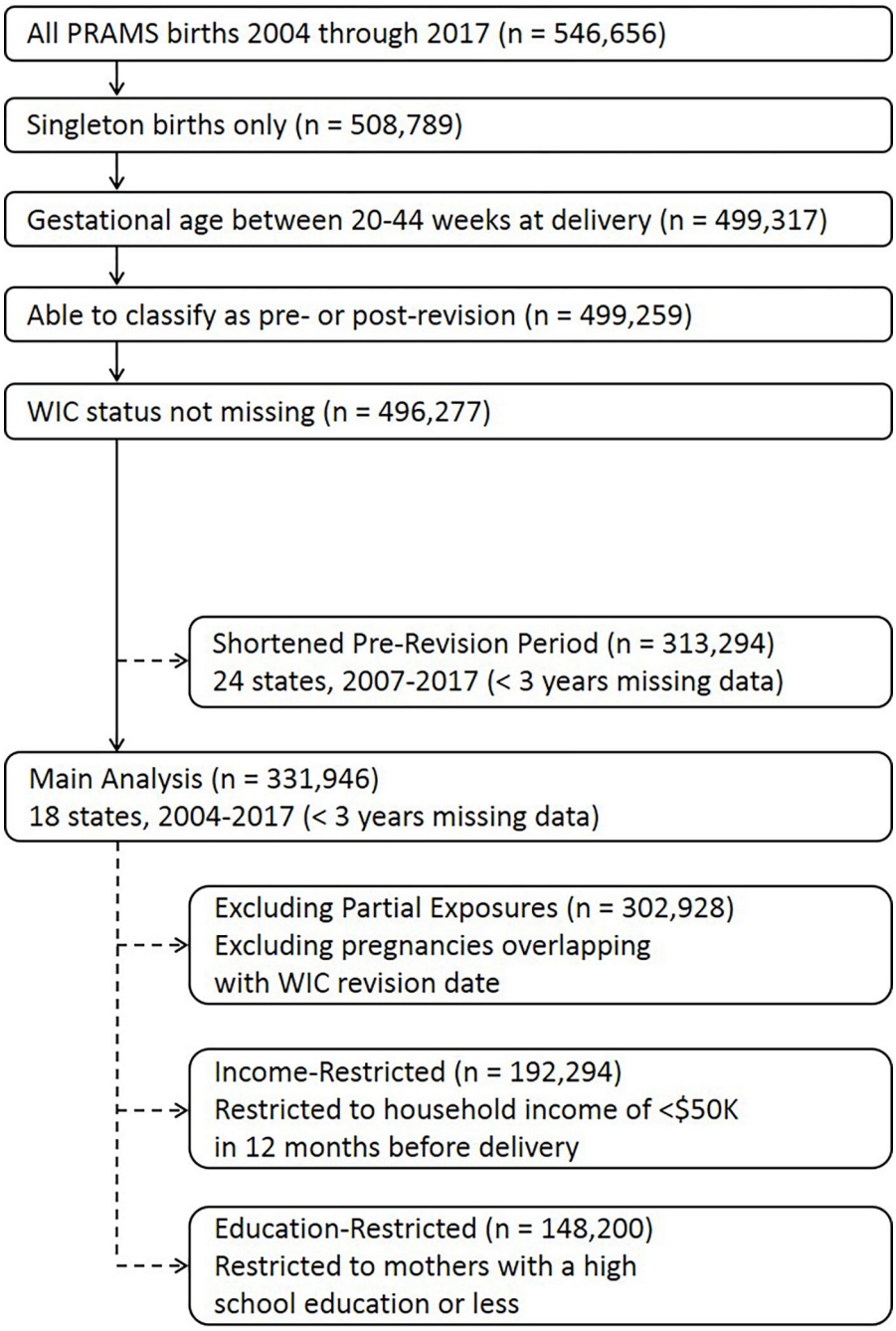

Figure 1. Sample Selection Flowchart.

The Pregnancy Risk Assessment Monitoring System (PRAMS) dataset includes linked birth certificate and mothers' survey responses. WIC indicates Special Supplemental Nutrition Program for Women, Infants, and Children.

Table 1.

Sample Demographics by WIC Receipt and Revision Time Period[a]

	WIC recipient, n (%)		Non-recipient, n (%)	
	Pre-revision	Post-revision	Pre-revision	Post-revision
Characteristic	**N = 79,208**	**N = 81,865**	**N = 85,806**	**N = 85,067**
Age (years)				
< 25	42,133 (53.2)	35,446 (43.3)	16,089 (18.8)	12,102 (14.2)
25–29	19,560 (24.7)	22,551 (27.5)	25,170 (29.3)	25,011 (29.4)
30–34	10,654 (13.5)	14,780 (18.1)	25,286 (29.5)	29,327 (34.5)
35+	6,855 (8.7)	9,085 (11.1)	19,256 (22.4)	18,625 (21.9)
Race/ethnicity				
White	31,374 (40.3)	28,811 (35.8)	54,854 (65.3)	53,940 (64.3)
Black	15,775 (20.3)	17,769 (22.1)	7,192 (8.6)	6,607 (7.9)
Asian	4,157 (5.4)	4,583 (5.7)	10,310 (12.3)	9,369 (11.2)
Hispanic/Latina	18,863 (24.3)	20,028 (24.9)	7,405 (8.8)	7,742 (9.2)
Other	7,595 (9.8)	9,311 (11.6)	4,289 (5.1)	6,262 (7.5)
Years of education				
< 12 years	24,189 (31.1)	20,906 (26.0)	6,023 (7.1)	4,224 (5.0)
= 12 years	31,853 (40.9)	29,779 (37.0)	18,281 (21.6)	12,945 (15.4)
> 12 years	21,787 (28.0)	29,872 (37.1)	60,288 (71.3)	66,856 (79.6)
Married	31,935 (40.3)	31,841 (39.1)	70,413 (82.1)	69,195 (81.6)
Annual household income >$50,000	3,991 (5.7)	4,044 (5.7)	51,450 (63.3)	51,601 (64.5)
Medicaid during pregnancy	56,732 (72.6)	60,741 (75.5)	12,547 (14.8)	13,968 (16.7)
Parity				
0	33,801 (42.9)	31,718 (39.0)	37,150 (43.5)	36,885 (43.7)
1	21,874 (27.8)	22,744 (28.0)	27,870 (32.6)	27,806 (32.9)
2	12,714 (16.1)	14,300 (17.6)	13,016 (15.2)	12,271 (14.5)
3+	10,409 (13.2)	12,600 (15.5)	7,394 (8.7)	7,458 (8.8)

Abbreviation: WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]N = 331,946. Main analysis sample includes the mothers of singleton infants who were live-born in select PRAMS participating states from 2004 through 2017 with a gestational age between 20–44 weeks. Sample demographics based on unimputed data.

Table 2.

Sample Health Characteristics by WIC Receipt and Revision Time Period[a]

	WIC recipient		Non-recipient	
	Pre-revision	Post-revision	Pre-revision	Post-revision
Characteristic	**N = 79,208**	**N = 81,865**	**N = 85,806**	**N = 85,607**
Panel A. Maternal Outcomes				
Gestational diabetes, n (%)	9,101 (11.5)	10,505 (12.8)	8,480 (9.9)	8,407 (9.9)
Gestational weight gain[b], n (%)				
Less than recommended	19,624 (27.2)	22,108 (29.2)	19,632 (23.7)	20,541 (24.9)
Within recommended range	21,318 (29.5)	21,000 (27.7)	29,668 (35.8)	27,425 (33.2)
More than recommended	31,299 (43.3)	32,601 (43.1)	33,655 (40.6)	34,676 (42.0)
Panel B. Infant Outcomes				
Gestational age, weeks, mean (SD)	38.1 (3.5)	38.2 (3.3)	38.3 (3.2)	38.5 (3.1)
Preterm birth, n (%)	17,610 (22.4)	16,468 (20.1)	16,992 (19.9)	14,993 (17.7)
Fetal growth, n (%)				
AGA	56,707 (72.0)	58,988 (72.3)	63,728 (74.6)	63,409 (74.8)
SGA	15,013 (19.1)	14,791 (18.1)	13,147 (15.4)	12,946 (15.3)
LGA	7,035 (8.9)	7,811 (9.6)	8,577 (10.0)	8,419 (9.9)
Extended hospitalization, n (%)	13,163 (17.0)	13,267 (16.6)	12,467 (14.8)	11,882 (14.4)
Ever breast feeding, n (%)	55,635 (73.2)	63,135 (80.3)	71,162 (85.7)	76,081 (92.0)

Abbreviations: WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; AGA, Appropriate for gestational age; SGA, Small for gestational age; LGA, large for gestational age

[a]N = 331,946. Main analysis sample includes the mothers of singleton infants who were live-born in select PRAMS participating states from 2004 through 2017 with a gestational age between 20–44 weeks. Sample health characteristics based on unimputed data.

[b]Gestational weight gain categories are based on 1990 recommendations of the Institute of Medicine.

Table 3.

Association of Revised WIC Program with Maternal and Infant Outcomes[a]

Characteristic	Association of Revised WIC Program (95% CI)			
	Main Analysis N = 331,946	Shortened Pre-revision Period Beginning 2007[b] N = 313,294	Excluding Pregnancies Overlapping with Revision[c] N = 302,928	Main Analysis with Adjustments for Time-Varying Policies[d] N = 331,946
Panel A. Maternal Outcomes				
Gestational weight gain[e]				
Less than recommended	0.60 (−0.51, 1.71)	1.16 (0.21, 2.11)	0.70 (−0.46, 1.86)	0.60 (−0.51, 1.71)
Within recommended range	0.70 (−0.09, 1.48)	0.44 (−0.36, 1.24)	0.74 (−0.18, 1.66)	0.70 (−0.09, 1.48)
More than recommended	−1.29 (−2.03, −0.56)	−1.60 (−2.29, −0.91)	−1.44 (−2.23, −0.66)	−1.29 (−2.03, −0.56)
Panel B. Infant Outcomes				
Gestational age (weeks)	−0.01 (−0.11, 0.09)	0.01 (−0.08, 0.10)	−0.01 (−0.11, 0.10)	−0.01 (−0.11, 0.09)
Preterm birth	−0.54 (−1.73, 0.64)	−0.52 (−1.58, 0.54)	−0.53 (−1.72, 0.66)	−0.54 (−1.73, 0.64)
Fetal growth				
AGA	0.38 (−0.69, 1.45)	−0.06 (−1.07, 0.96)	0.29 (−0.85, 1.43)	0.38 (−0.69, 1.45)
SGA	−0.70 (−1.83, 0.43)	−0.33 (−1.42, 0.76)	−0.59 (−1.77, 0.59)	−0.70 (−1.83, 0.43)
Extended Hospitalization	−0.24 (−1.38, 0.89)	−0.28 (−1.22, 0.65)	−0.13 (−1.25, 0.99)	−0.24 (−1.38, 0.89)
Ever breast feeding	1.18 (0.28, 2.08)	1.04 (−0.05, 2.12)	1.59 (0.70, 2.49)	1.18 (0.28, 2.08)

Abbreviations: WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; AGA, Appropriate for gestational age; SGA, Small for gestational age

[a]Values in table represent the coefficients on the interaction term between WIC receipt and post-revision time period. Coefficients for binary outcomes were multiplied by 100 and therefore represent a change in percentage points. Analysis involved multivariable linear models (i.e. linear probability models for binary outcomes) with maternal fixed effects and robust standard errors clustered by state of residence. Covariates included year, age, race/ethnicity, years of education, marital status, household income in 12 months prior to delivery, receipt of Medicaid during pregnancy, and parity. Results are multiple-imputation estimates from 50 imputations of missing covariates. Sample size varies for each model due to differences in outcome missingness. We report the full sample size for each sensitivity analysis.

[b]Sensitivity analysis for shortened pre-revision period includes data from 24 states from 2007–2017.

[c]Sensitivity analysis excludes pregnancies that overlap with the WIC revision implementation date in the woman's state of residence. This aims to eliminate partial exposures to the revision from the analysis.

[d]Sensitivity analysis using primary analytic sample. In addition to adjustments described in Footnote A, these models further adjust for time-varying polices that may impact WIC access and maternal and child health outcomes: state EITC rate by year, state food stamp/SNAP caseload by year, state AFDC/TANF caseload by year, gross state product per capita by year, state unemployment rate by year, and exposure to state expansion of Medicaid by year.

[e]Gestational weight gain categories are based on 1990 recommendations of the Institute of Medicine.