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Impact of the 2009 WIC revision on infant and maternal health: A quasi-experimental multi-state study

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Abstract

Improving food security and dietary quality during pregnancy is vital for maternal and infant health. Poor nutrition can lead to adverse fetal development and complications for women. In 2009, the Special Supplemental Nutrition Program for Women, Infant, and Children (WIC), a US safety net program for low-income pregnant, breastfeeding or postpartum women and young children, was revised to improve dietary quality, promoting intake of whole grains, fruits, and vegetables. Prior studies found the revision improved dietary quality, but its impact on downstream health is less understood. We analyzed 2008–2012 national birth certificate data (N=11,855,417) and employed a quasi-experimental difference-in-differences analysis to examine pre-post trends in outcomes among women predicted to be eligible for WIC (treatment group) while “differencing” out pre-post trends among predicted WIC-ineligible women (control group). Outcomes include infant birth weight and size for gestational age, and maternal gestational-diabetes-mellitus (GDM) and gestational-weight gain (GWG). The 2009 WIC

revision was associated with small reductions in birth weight (−3.52 grams; 95%CI, −4.75 to −2.30) and small-for-gestational-age (−0.08% points; 95%CI, −0.15, −0.01), and GWG (−0.05 pounds; 95%CI, −0.09, −0.02). While the results were robust to most sensitivity tests, they were not for some and therefore should be interpreted cautiously. Disparities emerged in the impact on GDM and GWG across subgroups. The limited evidence of positive effects on infant and maternal health underscores the need for ongoing research to better understand the impact of the 2019 WIC revision, including implementation factors and program design, on downstream health.

Introduction

Improving food security and diet quality during pregnancy is important, given the far-reaching effects of maternal nutrition during this critical window of the life course on the health of both women and their children. In the short term, poor maternal nutrition has been associated with adverse fetal development, resulting in low birthweight and preterm birth.(Gete et al., 2020; Lechtig et al., 1975; Saenger et al., 2007) Also, it can lead to maternal complications, such as gestational-diabetes-mellitus (GDM) and gestational-weight-gain (GWG) outside the recommended range.(Diemert et al., 2016; McIntyre et al., 2019; Silva-Zolezzi et al., 2017) These adverse maternal health conditions can contribute to the long-term development of chronic diseases.(Christian & Stewart, 2010; Wu et al., 2004) For example, pregnant women with GDM are more likely to develop type 2 diabetes, (Kim et al., 2002) and children with low birth weight have increased heart disease and premature mortality in later life.(Negrato & Gomes, 2013) Due to disparities in upstream socioeconomic factors, US women in historically marginalized groups (e.g., Black and Hispanic women, those with lower education) are more likely to experience poor maternal nutrition, increasing the risk of adverse maternal health and having low birthweight infants. (Headen et al., 2015) This intergenerational transmission of inequity may contribute to the persistent health disparities in the U.S.(Aizer & Currie, 2014) Consequently, interventions and policies that improve food security and nutrition during pregnancy are essential to prevent the intergenerational perpetuation of health disparities.

The Special Supplemental Nutrition Program for Women, Infant, and Children (WIC), initiated in the 1970s, is among the largest US safety net programs aimed at improving nutrition for low-income pregnant and postpartum women and children younger than 5. (Oliveira, 2009) The program provides nutrition supports (including food packages and breastfeeding education) to approximately seven million women and children every month. (United States Department of Agriculture, 2023) In 2009, the WIC food package was revised for the first time to match the current dietary guidelines based on recommendations of the Institute of Medicine (now known as the National Academy of Medicine).(Institute of Medicine, 2006) The food package was modified to include more whole grains and less saturated fat (e.g., reduced-fat milk).(Institute of Medicine, 2006) For the first time, women also received a cash value voucher specifically for fruits and vegetables, valued at \$8 for pregnant women and \$10 for breastfeeding women.(US Department of Agriculture Food and Nutrition Service, 2014) The revised food packages were designed to be cost-neutral for WIC, meaning increases in expenditures on healthier food had to be counterbalanced by reductions in expenditures elsewhere (e.g., juice, whole milk).(Hanson & Oliveira, 2009)

For example, in fiscal year 2010 right after the new package was implemented, nearly 10% of the total federal costs of WIC food (or \$614 million) were attributable to newly introduced spending on fruits and vegetables. This offset other spending on presumably less healthful food; consequently, overall the revision led to changes in food families brought home.(Vericker et al., 2016) Empirical work has confirmed improved dietary quality among WIC participants.(Hamad, Batra, et al., 2019; Oh et al., 2016; Schultz et al., 2015)

However, few studies have examined whether this resulted in improved maternal or infant health. One study found reduced maternal preeclampsia and increased likelihood of recommended GWG and appropriate-for-gestational-age birthweight in California.(Hamad, Collin, et al., 2019) Another study using national data found reductions in more-than-recommended GWG for women.(Pulvera et al., 2022) Few studies have examined the effects on perinatal outcomes in a large multi-state sample. To fill this gap, we utilized national birth certificate data and conducted a rigorous quasi-experimental analysis to examine the effects of the 2009 WIC revision on perinatal health (infant birthweight, GDM, and GWG), including subgroup analyses to examine differential effects among historically marginalized groups. Additionally, we explored whether the revision affected program participation among pregnant women. While the improved package could encourage greater participation, program spending was capped and the revision was intended to be cost-neutral, which may have limited health impacts. These questions are particularly informative for ongoing policymaking in the context of recent revisions during the COVID-19 pandemic to further expand the value of the WIC fruit and vegetable vouchers.

Methods

Data and sample

For analysis of perinatal health, we used birth certificate data from the National Vital Statistics System,(National Center for Health Statistics) which include every US birth (about 3.5 million per year). In 2003, birth certificate forms were revised to standardize the data collection process and enhance completeness and accuracy,(National Center for Health Statistics) although timing of implementation varied across states (Supplemental Table S1). Because GDM is an outcome of interest and only available on the new birth certificate forms, and because our analytic strategy requires using time periods before and after the 2009 WIC revision, our main sample was limited to 27 states that implemented the new form in or before 2008. We also restricted the data to births occurring to mothers whose second trimester began between January 2008 and December 2012 to capture the time period immediately before and after the revision was implemented; hence, our sample included two years of pre-treatment data and three years of post-treatment data. We further excluded mothers with missing covariates. The final sample size was 11,855,417. (See Supplemental Figure S1, sample selection flowchart.)

Exposure

For the perinatal health analysis, we defined a woman to have been exposed to the WIC revision if she was predicted to be WIC-eligible (explained below) and her second trimester started after the 2009 revision (i.e., January 2010 or later). The majority of pregnant women

enroll in WIC during their second trimester,(United States Department of Agriculture, 2018) and this also captures women for whom at least half the pregnancy occurred after the revision. Previous studies have shown that the later stage of pregnancy is critical for food and nutrition, as it is when the infant experiences the most rapid growth and development, along with significant weight gain for both mothers and infants.(Cortés-Albornoz et al., 2021; da Mota Santana et al., 2021)

Notably, we used eligibility for WIC instead of WIC participation for several reasons. First, self-reported WIC participation was only available in national birth certificate data from 2010 onwards, and several states did not report this variable until later years. Second, self-reported participation in social programs is often incorrect.(Celhay et al., 2022). Third, using WIC eligibility helps avoid confounding from selection into WIC, as individuals may participate based on unobserved factors correlated with negative birth outcomes.(Bitler & Currie, 2005) Additionally, using WIC eligibility instead of WIC participation is analogous to an “intent-to-treat” design, which offers a more realistic picture of real-world conditions, accounting for potential confounding that may arise due to incomplete take-up. This approach can be more relevant to policymakers. We therefore imputed WIC eligibility as a proxy for exposure to the WIC revision.

To impute WIC eligibility, we used the US Census Bureau’s Current Population Survey (CPS) Annual Social and Economic Supplement to create a probabilistic algorithm determining whether a woman was likely to be eligible for WIC based on characteristics available in CPS and birth certificate data. We then categorized each woman as WIC-eligible if her predicted probability was greater than 0.5; otherwise, she was classified as WIC-ineligible. Additional details are provided in Supplement.

Outcomes

For perinatal health, we examined infant and maternal outcomes that we hypothesized would be affected by the WIC revision. These included infant birthweight as a continuous variable (grams), and categorized to capture binary variables for small-for-gestational-age (SGA), large-for-gestational-age (LGA), and appropriate-for-gestational-age (AGA). These categories are defined using birth weight percentile cut-offs based on gestational age (i.e., 10th percentile for SGA and 90th percentile for LGA). Maternal outcomes included a binary variable for gestational-diabetes-mellitus (GDM), collected directly from the medical record using the facility worksheet, and a continuous variable for gestational-weight-gain (GWG, pounds), derived from mother’s pre-pregnancy weight and mother’s weight at delivery. We did not include low-birthweight (LBW), often examined in prior studies, since this may be conflated with preterm birth.

Covariates

We adjusted for individual and state characteristics that serve as potential confounders. Individual-level characteristics included age, race/ethnicity, education level, nativity, marital status, and parity. Categories for race/ethnicity were non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian/Pacific Islander, and non-Hispanic other groups. State-level covariates included birth rate (natural logarithm), unemployment rate, SNAP

recipients/capita, TANF recipients/capita, state earned income tax credit rate as a percent of the federal credit, and state Medicaid income eligibility thresholds for pregnant women as a percent of the federal poverty guideline.(University of Kentucky Center for Poverty Research) We also included fixed effects for time (indicator variables for month and year) to account for secular trends in outcomes. WIC is a federal program, with standardized benefits for all participants nationwide. However, it is implemented at the state and local level and therefore program practices (e.g., specific brands, and quantities within some ranges) vary by geography. To account for these differences, we additionally included fixed effects for state, which accounts for all observed and unobserved time-invariant state-level confounders.

Primary Analysis: Effects on Perinatal Health

We first tabulated sample characteristics for predicted WIC-eligible (treatment group) and WIC-ineligible (control group) women whose second trimester occurred before or after the WIC revision. We then examined the association of the revision with each outcome using difference-in-differences (DID) analysis, a quasi-experimental method widely employed to assess policy effects while accounting for underlying temporal trends.(Dimick & Ryan, 2014) The 2009 WIC revision created a natural experiment whereby WIC-eligible women whose second trimester started after 2009 were exposed to the revision, while those whose second trimester started in or before 2009 were unexposed. DID compared the pre-post differences in outcomes among WIC-eligible women, accounting for secular trends in outcomes by “differencing out” the pre-post differences in outcomes among WIC-ineligible women. By focusing on how much the treatment affects the changes in outcomes rather than the absolute levels, the DID estimator is unbiased as long as the underlying assumptions are met, that is, trends in outcomes would be similar between treatment and control groups without the intervention, even though groups may differ in many aspects.

In practice, our DID model involves the following equation for individual i in state s and time t :

$$Y_{ist} = \beta_0 + \beta_1 WICELIG_{ist} \times Post_t + \beta_2 WICELIG_{ist} + \beta_3 X_{ist} + \beta_4 Z_{st} + \beta_5 Time_t + \beta_6 State_s + \epsilon_{ist}$$

Y_{ist} represents an outcome of interest. $WICELIG_{ist}$ is a binary variable indicating predicted WIC eligibility. $Post_t$ is a binary variable indicating whether the second trimester occurred after 2009 (i.e., January 2010 or later). X_{ist} represents individual-level covariates. Z_{st} represents time-variant state-level covariates. $Time_t$ represents month-year indicator variables (i.e., fixed effects) for start of the second trimester. $State_s$ represents state fixed effects. Robust standard errors accounted for heteroskedasticity. The coefficient of interest, β_1 , captures the change in the outcome attributable to the implementation of the new food package. See Supplement for details about this assumption and others that underlie DID analyses.

Secondary Analyses

We performed subgroup analyses to examine whether the effects of the WIC revision differed by race/ethnicity, nativity, and education levels. These groups may differ in

their access to resources due to structural racism and discrimination or because they are differentially ineligible for other safety net programs and thus may respond differently to the 2009 revision. Specifically, we stratified the sample based on these characteristics to estimate effects separately for each subgroup.

We also conducted several sensitivity tests to assess the robustness of our findings. These include: setting a higher threshold for the imputed cutoff of WIC eligibility, recoding the post-period to start in April 2009, including different lengths of pre-treatment periods in the main model, applying a recently developed method to test the sensitivity of our results to possible violations of the parallel trends assumption, and examining the possibility of an additional generalized DID analysis to leverage the staggered timing of the adoption of the WIC food package across states(see Supplement).

A final feature of our analysis considers the impact of the new package on program participation among pregnant women (“first-stage”). Unlike the primary specifications outlined earlier (i.e., eligible vs. ineligible), we used a generalized DID model that leveraged the geographical and temporal variations in the adoption of the new package. This is because we only had aggregated participation data and lacked individual-level data among those giving birth to predict eligibility among pregnant women. To be more specific, the analysis involves comparing WIC participation for pregnant women per birth in states that adopted the new package with those in states that had not adopted it. See Supplement for more details about the method.

Results

Sample Characteristics

Table 1 presents descriptive statistics by imputed WIC eligibility. Compared to WIC-ineligible women, WIC-eligible women were more likely to be Black or Hispanic, younger than 35, unmarried, and foreign-born; with lower educational attainment and higher parity.

In terms of perinatal health, infants born to WIC-eligible women were more likely to have worse birth outcomes, such as lower birthweight and greater risk of SGA. However, compared to WIC-ineligible women, WIC-eligible women were less likely to have GDM and had less GWG. Among all the outcomes, GDM exhibited a more pronounced increase after 2010, with a larger increase observed in the WIC-eligible group (Figure 1).

Effects of the WIC Revision on Infant and Maternal Health

For infant health (Table 2), the WIC revision was associated with reduced birthweight (−3.52 grams; 95%CI, −4.75 to −2.30) and probability of SGA (−0.08% points; 95%CI, −0.15, −0.01). For maternal health, GWG decreased (−0.05 pounds; 95% CI, −0.09, −0.02). Relative to the baseline means, these represent changes of −0.11%, −0.7%, and −0.2% respectively. We were unable to rule out the null hypothesis that there was no association of the revised food package with the other infant outcomes or with maternal GDM. Of note, the results for birthweight and GWG should be interpreted cautiously, as the estimated effects for some pre-treatment periods were significantly different from zero, potentially violating

the parallel trends assumption. See Supplement for further discussion and full model results (Supplemental Table S9).

Subgroup Effects

Table 3 shows analyses stratified by race/ethnicity. After the WIC revision, non-Hispanic White women experienced increased LGA (0.11% points; 95%CI: 0.07, 0.22) and reduced GWG (−0.23 pounds; 95%CI: −0.28, −0.18). Hispanic women experienced reduced SGA (−0.24% points, 95%CI: −0.41 to −0.07), increased AGA (0.25% points, 95%CI: 0.03 to 0.48), increased GDM (0.21% point; 95%CI: 0.10 to 0.33), and increased GWG (0.12 pounds; 95%CI: 0.04, 0.20). Changes in GDM was equivalent to changes from baseline of 5.3% for women of Hispanic. The effect sizes for other estimates were smaller, ranging from less than 0.1% to 2%. No significant changes were found among non-Hispanic Black women, Asian/Pacific Islander women, and women of other races/ethnicities.

In subgroup analyses by nativity (Table 4), foreign-born women experienced reduced infant birthweight (−4.32 grams; 95%CI: −6.84, −1.81), increased GDM (0.19% points; 95%CI: 0.08, 0.31) and increased GWG (0.14 pounds; 95%CI: 0.07, 0.20). US-born women experienced reduced SGA (−0.11% points; 95%CI: −0.19, −0.03), reduced GDM (−0.06% point, 95% CI: −0.11, −0.003), and reduced GWG (−0.18 pounds; 95%CI: −0.22, −0.14). In subgroup analyses by education (Table 4), the WIC revision was associated with reduced birthweight (−6.30 grams; 95%CI: −7.93, −4.66) and GDM (−0.10% points; 95%CI: −0.16, −0.03) among women with lower educational attainment. Women with higher education had increased GWG (0.38 pounds; 95%CI: 0.20, 0.57).

Sensitivity tests

The majority of our primary findings remained robust in sensitivity analyses. However, our results were sensitive to violations of the parallel trends assumption. Additionally, generalized DID analyses were not implemented eventually due to violations of the parallel trends assumption for all outcomes (see Supplement).

Effects on WIC Participation

We found no significant increase in participation with the WIC revision (Supplement Table S7).

Discussion

This study is among the first to examine the effects of the 2009 WIC revision on perinatal health. We used a rigorous quasi-experimental analysis and impute WIC eligibility as exposure. We found limited evidence that the revision had large positive effects on infant and maternal health. Instead, we found small reductions in infant birthweight and SGA. Although these effects size are small (ranging from −0.2% to 0.1%) and thus may not be clinically meaningful at the individual level, they may represent meaningful (albeit modest) changes at the population level.(Guyatt et al., 2002) The effect sizes are slightly smaller to those found in recent studies examining the effect of the WIC revision on perinatal health, which used different study samples and methods.(Hamad, Collin, et al., 2019; Pulvera et

al., 2022) The subgroup analyses showed inconsistent associations for GDM and GWG by race/ethnicity, nativity, and education.

In terms of mechanisms for the observed effects, previous work has found the revision was associated with increased consumption of whole grains and decreased consumption of white bread and juice.(Oh et al., 2016; Schultz et al., 2015) Results about the impact on fruit and vegetable consumption were less consistent, with national or state studies showing positive effects while local studies showing little effects.(Zhang et al., 2020) A handful of studies have also found increased availability (i.e., supply) of healthy food and beverages in authorized WIC stores.(Schultz et al., 2015) In terms of changing program participation as a mechanism, we did not find that the WIC revision was associated with WIC participation by pregnant women. This is consistent with the USDA reports about how new spending on the food package worked around implementation of the new package. Improvements to the food package, such as the fruit and vegetable cash voucher, might attract more eligible women to participate in the program, or might encourage existing participants to redeem a larger share of their benefits. However, the 2009 revision was intended to be cost-neutral, and states' WIC funding was not increased in the short run with the revision. Thus, spending on the cash value voucher had to be offset by reduced state funding on other food. The fact that the revision was mostly focused on encouraging more healthful food consumption and not increasing spending on food overall may explain some of our contradictory and null findings. For example, it may have prevented some participants from purchasing the foods they prefer. This suggests less substantive impacts would be expected, compared to more recent pandemic-era expansions to the size of the cash value voucher that were not revenue neutral. Thus, results need to be interpreted cautiously compared to predictions of increasing spending in the program.

Only a few studies have evaluated the effects of the package revision on more downstream outcomes such as maternal and infant health. Comparing findings across these studies face challenges due to variations in samples, study timeframes, and study design:

Our findings regarding birthweight-related outcomes largely mirror those of a study evaluating the effects of the 2009 WIC revision using 2006–2012 California birth certificate data.(Hamad, Collin, et al., 2019) Specifically, both studies found reduced birthweights and SGA and increased AGA. While the prior study also found reductions in LGA, suggesting that the reductions in birthweight might be explained by fewer LGA infants, our multi-state study did not find similar results for LGA. Another study using multi-state data from the CDC's Pregnancy Risk Assessment and Monitoring Survey (PRAMS) did not find changes in SGA or AGA after the 2009 revision.(Pulvera et al., 2022)

For GDM, while we observed a null effect of the 2009 revision on GDM in the overall sample, we found differential effects across racial/ethnic, nativity, and education groups. Specially, we noted increased GDM among foreign and Hispanic women, decreased among US-born women and those without a college degree. The disparity raises questions about the underlying mechanisms driving these differences. Factors such as genetic, lifestyle, social-cultural, and other environmental factors may contribute,(Chen et al., 2019) yet further research is necessary to elucidate the complex pathways linking the WIC revision to GDM.

Our findings differ slightly from those of the California study, which also found a null effect on GDM in the overall population but reduced effects among Black, Hispanic, Asian, and other racial/ethnic groups. However, their results of GDM should be interpreted cautiously due to potential violations of the parallel trends assumption. Another study using PRAMS data also identified similar violation and therefore did not assess the effects on GDM.

Regarding GWG, both of the other studies reported reductions in more-than-recommended GWG for mothers.(Hamad, Collin, et al., 2019; Pulvera et al., 2022) This finding is significant considering the link between excessive GWG and increased risk of pregnancy complications, adverse birth outcomes, as well as increased obesity and chronic disease later in life for both mothers and children.(Baran et al., 2020; Bodnar et al., 2010; Simko et al., 2019) In our study, we similarly observed reductions in GWG. However, because of the lack of pre-pregnancy body mass index measurements in birth certificate data, we were unable to determine whether the reductions in GWG were primarily driven by reduced more-than-recommended GWG.

Several factors may potentially explain the lack of strong positive findings. First, research has shown that mothers' nutritional status just before conception and during early pregnancy can influence pregnancy outcomes, such as low birthweight and SGA.(Ramakrishnan et al., 2012) However, the majority of women enroll in WIC during their second trimester, which means they miss the important early intervention stage. Second, there may be spillover of WIC benefits to other family members.(Bitler et al., 2022; Robinson, 2013; Ver Ploeg, 2009) If pregnant women passed food benefits to other family members, maternal health and infant health may not have improved as much as expected from the increased fruit and vegetable redemption. We investigated this by running the same analysis among single first-time mothers. We observed slightly larger coefficients indicating a reduced probability of SGA and GDM (Supplement Table S8); however, these findings are not statistically significant. Third, it is also possible that increased fruit and vegetable acquisitions and reduced other WIC food acquisition were not sufficiently large enough nutritional changes in magnitude to affect the birth outcomes we study. Additionally, our findings of a small reduction in infant birthweight and GWG may result from decreased overall caloric intake, an important factor influencing GWG and infant birthweight, due to increased consumption of fruit and vegetable and reduced consumption of other food.

There are several limitations of this study. First, our measure of predicted WIC eligibility may lead to some misclassification that could attenuates results towards the null if classical in nature, even while reducing issues related to self-selection; nevertheless, linkage of administrative data on WIC participation is infeasible at this time but can be explored in the future. Second, data limitations (i.e., lack of income data) prevented us from using alternative approaches, such as comparing WIC-eligible women with "near-eligible" women, who would be more comparable. The violation of the parallel trends assumption in the staggered design prevented us from leveraging the geographical and temporal variation in policy adoption. Third, we were only able to include data from 27 states, as the key outcome, GDM, was unavailable in other states adopting the new birth certificate after 2009. Since WIC program administration, food package design, and the characteristics of pregnant women vary by state, our results might not generalize to other states or nationwide. Fourth,

although the largest advantage of the birth certificate data is its comprehensiveness and generalizability, there are known data quality issues with the reporting of GDM and other health outcomes on birth certificates,(Haghighat et al., 2016; Reichman & Schwartz-Soicher, 2007) and thus may be subject to measurement error. Finally, our analysis of program participation was limited by the aggregated nature of the data and the lack of specific details (e.g., on pregnancy status), but unfortunately more granular data is not available at this time.

Conclusion

Our study contributes to the growing body of evidence examining the effects of the 2009 WIC revision on maternal and infant health. While most studies found the revision improved diary quality for some program participants, we found limited evidence of large positive effects on short-term infant and maternal health. This underscores the importance of continued research in this area to enhance our understanding of the potential benefits and limitations of the 2009 revision—including its cost-neutrality—and to inform policy and programmatic efforts aimed at improving maternal and infant health among vulnerable populations. It may be that larger improvements—such as the \$25-\$45 fruit and vegetable vouchers implemented during the COVID-19 pandemic—may be more impactful.(United States Department of Agriculture, 2022)

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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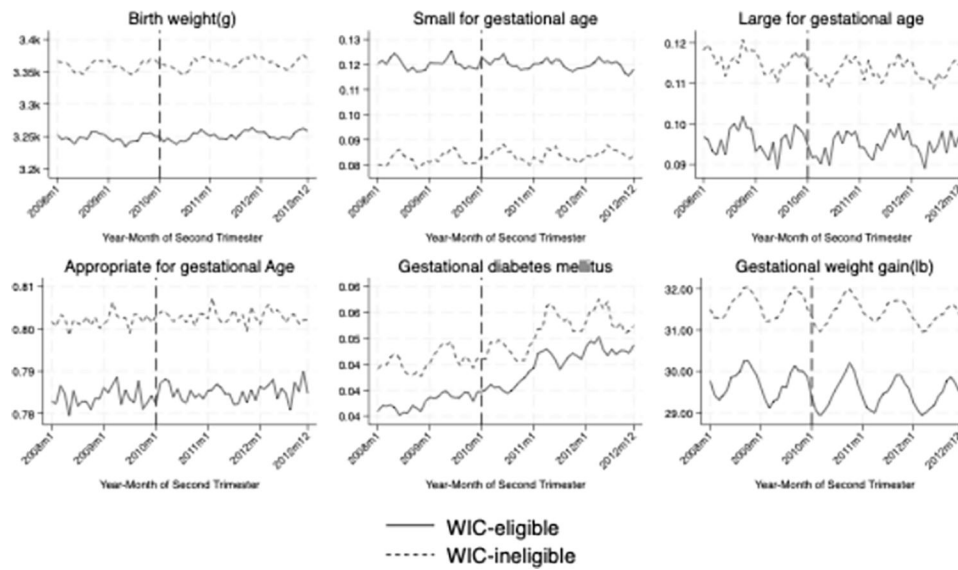


Figure 1.

Trends in outcomes by WIC eligibility from January 2008 to December 2012

Note: Data were drawn from 2008–2012 US birth certificates (N = 11,855,417 women in 27 states). Vertical lines indicate the time of the policy change, i.e., January 2010. WIC eligibility was imputed using self-reported demographics.

Table 1.
Sample characteristics before and after 2009 WIC revision, by WIC eligibility

	WIC-eligible		WIC-ineligible	
	Mean (SD) or %		Mean (SD) or %	
	Before	After	Before	After
Health outcomes				
Birthweight (grams)	3248(539)	3251(542)	3360(517)	3364(518)
Small for gestational age	12.0	12.0	8.2	8.4
Large for gestational age	9.6	9.5	11.6	11.3
Appropriate for gestational age	78.4	78.5	80.2	80.3
Gestational diabetes mellitus	3.8	4.5	4.6	5.2
Gestational weight gain (pounds)	30(16)	29(15)	32(14)	31(14)
Individual characteristics				
Race/ethnicity				
White	34.1	35.3	72.7	73.2
Black	19	19.4	5.1	4.9
Hispanic	43	40.9	12.2	11.2
Asian/Pacific Islander	3.1	3.5	9.7	10.3
Other	0.9	0.9	0.3	0.3
Age 35+ years	7.7	8.8	21.4	21.7
Education				
Less than high school	38.8	33.0	0.2	0.1
High school	38	39.0	12.5	8.9
Some college	22.1	26.3	32.7	31.3
College	1.1	1.7	54.6	59.7
Married	28.1	29.2	96.5	96.4
Foreign born	32.5	29.9	18.3	18.1
Birth parity				
Nulliparous	37.4	36.4	44.9	46.0
Primiparous	26.9	27.0	37.0	37.1
Multiparous	35.7	36.6	18.0	16.9
State characteristics				
Birth rate (log)	2.6(0.1)	2.6(0.1)	2.6(0.1)	2.5(0.1)
Unemployment rate (%)	9.0(3.0)	9.2(2.6)	8.6(2.8)	8.6(2.4)
% SNAP/capita	5.0(1.6)	6.9(1.9)	5.0(1.6)	6.8(1.9)
% TANF/capita	0.7(0.5)	0.7(0.5)	0.7(0.4)	0.7(0.5)
EITC rate (as % of the federal EITC)	4.4(9.2)	4.3(9.3)	4.7(9.4)	4.2(9.1)
Medicaid eligibility income cutoff (as % of the FPG)	74.3(39.3)	78.1(42.1)	75.3(38.3)	79.1(41.1)
N	2649852	3966508	2137345	3101712

Abbreviations: SNAP: Supplemental Nutrition Assistance Program; TANF: Temporary Assistance for Needy Families; EITC: Earned Income Tax Credit; FPG: Federal Poverty Guideline

Notes: Data come from annual US birth certificate. Sample includes mothers whose second trimester started between 2008 and 2012 in 27 states that implemented the new birth certificate in or before 2008.

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Table 2.

Association of WIC revision with infant and maternal health

	Birthweight (grams)	Small for gestational age	Large for gestational age	Appropriate for gestational age	Gestational diabetes mellitus	Gestational weight gain (pounds)
WIC-eligible *Post-2009	-3.521 *** [-4.745, -2.297]	-0.081 * [-0.152, -0.010]	-0.004 [-0.075, 0.067]	0.085 [-0.010, 0.179]	0.032 [-0.016, 0.081]	-0.053 ** [-0.088, -0.019]
N	11,855,417	11,855,417	11,855,417	11,855,417	11,824,402	11,246,710
Baseline mean	3,248	12.0	9.6	78.4	3.8	29.7

95% confidence intervals in brackets.

*
p < 0.05,

**
p < 0.01,

p < 0.001

Abbreviations: SNAP: Supplemental Nutrition Assistance Program; TANF: Temporary Assistance for Needy Families; EITC: Earned Income Tax Credit

Notes: Data were drawn from 2008–2012 US birth certificates (N = 11,855,417 women in 27 states). WIC eligibility was imputed using self-reported demographics. Coefficients for binary outcomes were multiplied by 100 and therefore represent a change in percentage points. Binary variables include small/large/appropriate for gestational age and gestational diabetes mellitus. All models adjust for individual characteristics (mother's age, race/ethnicity, nativity, education, marital status, and parity), state characteristics (birth rate, unemployment rate, % TANF/capita, EITC rate, and Medicaid income eligibility threshold), and fixed effects for time (year-month) and state. Robust standard errors were used to address possible heteroscedasticity. Baseline mean represents value of outcomes among WIC-eligible mothers before the 2009 WIC revision.

Table 3.
Association of revised WIC food package with infant and maternal health, by mother's race/ethnicity

	Birthweight (grams)	Small for gestational age	Large for gestational age	Appropriate for gestational age	Gestational diabetes mellitus	Gestational weight gain (pounds)
<u>White</u>						
WIC-eligible *Post-2009	-2.618** [-4.349, -0.886]	-0.006 [-0.100, 0.088]	0.114* [0.007, 0.221]	-0.108 [-0.243, 0.027]	0.01 [-0.058, 0.077]	-0.228*** [-0.278, -0.178]
N	6,128,086	6,128,086	6,128,086	6,128,086	6,111,709	5,857,632
Baseline mean	3,281	11.6	10.0	78.4	3.5	32.3
<u>Black</u>						
WIC-eligible *Post-2009	-1.28 [-6.200, 3.640]	-0.285 [-0.598, 0.028]	-0.014 [-0.237, 0.208]	0.299 [-0.063, 0.662]	-0.036 [-0.200, 0.128]	-0.069 [-0.216, 0.078]
N	1,531,091	1,531,091	1,531,091	1,531,091	1,522,130	1,413,806
Baseline mean	3,101	16.7	7.1	76.1	3.2	29.2
<u>Hispanic</u>						
WIC-eligible *Post-2009	-3.868** [-6.759, -0.977]	-0.237** [-0.405, -0.068]	-0.014 [-0.184, 0.156]	0.251* [0.025, 0.477]	0.213*** [0.097, 0.329]	0.115** [0.035, 0.195]
N	3,370,879	3,370,879	3,370,879	3,370,879	3,366,472	3,197,908
Baseline mean	3,288	10.2	10.4	79.4	4.0	27.9
<u>Asian/Pacific Islander</u>						
WIC-eligible *Post-2009	-0.169 [-5.211, 4.873]	-0.11 [-0.463, 0.242]	0.077 [-0.173, 0.327]	0.033 [-0.378, 0.445]	-0.16 [-0.439, 0.119]	-0.067 [-0.194, 0.060]
N	748,989	748,989	748,989	748,989	747,841	705,319
Baseline mean	3,210	13.3	7.6	79.0	6.9	29.1
<u>Other</u>						
WIC-eligible *Post-2009	-7.681 [-27.060, 11.697]	-0.052 [-1.079, 0.976]	-0.52 [-1.730, 0.690]	0.571 [-0.916, 2.058]	-0.425 [-1.227, 0.376]	-0.359 [-0.943, 0.224]

	Birthweight (grams)	Small for gestational age	Large for gestational age	Appropriate for gestational age	Gestational diabetes mellitus	Gestational weight gain (pounds)
N	76,372	76,372	76,372	76,372	76,250	72,045
Baseline mean	3,322	9.9	13.7	76.4	5.0	29.8

95% confidence intervals in brackets.

*
p < 0.05,
**
p < 0.01,

p < 0.001

Notes: Data were drawn from 2008–2012 US birth certificates (N = 11,855,417 women in 27 states). WIC eligibility was imputed using self-reported demographics. Coefficients for binary outcomes were multiplied by 100 and therefore represent a change in percentage points. Binary variables include small/large/appropriate for gestational age and gestational diabetes mellitus. All models include individual characteristics (mother's age, race/ethnicity, nativity, education, marital status, and parity), state characteristics (birth rate, unemployment rate, % SNAP/capita, % AFDC/capita, EITC rate, and Medicaid income eligibility threshold), and fixed effects for time (year-month) and state. Robust standard errors were used to address possible heteroskedasticity. Baseline mean or % represents mean or % of outcomes among WIC-eligible mothers before the 2009 WIC revision.

Table 4.
Association of revised WIC food package with infant and maternal health, by mother's nativity and education level

	Birthweight (grams)	Small for gestational age	Large for gestational age	Appropriate for gestational age	Gestational diabetes mellitus	Gestational weight gain (pounds)
<i>US-born</i>						
WIC-eligible *Post-2009	-1.337 [-2.759, 0.084]	-0.109 ** [-0.191, -0.028]	0.054 [-0.028, 0.137]	0.055 [-0.055, 0.164]	-0.056 * [-0.109, -0.003]	-0.180 *** [-0.221, -0.139]
N	8,857,210	8,857,210	8,857,210	8,857,210	8,831,817	8,427,472
Baseline mean	3,220	13.1	8.9	78.0	3.2	31.1
<i>Foreign-born</i>						
WIC-eligible *Post-2009	-4.323 *** [-6.837, -1.809]	-0.109 [-0.258, 0.041]	0.025 [-0.122, 0.173]	0.084 [-0.115, 0.282]	0.192 ** [0.076, 0.308]	0.137 *** [0.070, 0.203]
N	2,998,207	2,998,207	2,998,207	2,998,207	2,992,585	2,819,238
Baseline mean	3,305	9.8	10.9	79.3	5.0	26.9
<i>Non-college degree</i>						
WIC-eligible *Post-2009	-6.296 *** [-7.933, -4.660]	0.044 [-0.053, 0.141]	-0.075 [-0.167, 0.017]	0.031 [-0.095, 0.157]	-0.095 ** [-0.158, -0.031]	0.043 [-0.005, 0.091]
N	8,741,987	8,741,987	8,741,987	8,741,987	8,718,083	8,280,877
Baseline mean	3,248	12.0	9.6	78.4	3.8	29.7
<i>College degree</i>						
WIC-eligible *Post-2009	0.820 [-6.248, 7.888]	-0.107 [-0.489, 0.274]	0.064 [-0.382, 0.509]	0.044 [-0.515, 0.603]	0.136 [-0.161, 0.433]	0.383 *** [0.199, 0.568]
N	3,113,430	3,113,430	3,113,430	3,113,430	3,106,319	2,965,833
Baseline mean	3,268	10.1	10.0	79.9	4.5	30.1

95% confidence intervals in brackets.

* p < 0.05,

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p < 0.01,
p < 0.001

Notes: Data were drawn from 2008–2012 US birth certificates (N = 11,855,417 women in 27 states). WIC eligibility was imputed using self-reported demographics. Coefficients for binary outcomes were multiplied by 100 and therefore represent a change in percentage points. Binary variables include small/large/appropriate for gestational age and gestational diabetes mellitus. All models include individual characteristics (mother's age, race/ethnicity, nativity, education, marital status, and parity), state characteristics (birth rate, unemployment rate, % SNAP/capita, % AFDC/capita, EITC rate, and Medicaid income eligibility threshold), and fixed effects for time (year-month) and state. Robust standard errors were used to address possible heteroskedasticity. Baseline mean or % represents mean or % of outcomes among WIC-eligible mothers before the 2009 WIC revision.