Supplementary Online Content

Hamad R, Collin DF, Baer RJ, Jelliffe-Pawlowski LL. Association of revised WIC food package with perinatal and birth outcomes: a quasi-experimental study. *JAMA Pediatr*. Published online July 1, 2019. doi:10.1001/jamapediatrics.2019.1706

eMETHODS

Sample Selection

To remove improbable birth weight and gestational age combinations, we excluded infants with birth weight for gestational age outside of three standard deviations from the mean.[1] We excluded mothers with five or more births during the study period, as many of these were biologically implausible and more likely represented errors in identifier variables in the California Office of State Health Planning and Development database. Women with unknown WIC participation were also excluded.

Prior work has demonstrated the validity of outcome and covariate data from birth certificates and hospital discharge records.[2-5] More recent years of linked birth certificate and hospital data have not yet been released by state agencies, limiting this study to data through 2012.

Difference-in-differences Analysis

In the primary analysis, difference-in-differences (DID) models included an interaction term between a binary variable for whether the mother was a WIC recipient during pregnancy (WIC) and a binary variable for whether the mother gave birth on or after February 2010 ($Post$). The equation for this model for a given outcome Y was specified as follows, for a given infant i born to mother m in year t:

$$Y_{imt} = \beta_1 WIC_{imt} \times Post_t + \beta_2 WIC_{imt} + \beta_3 Post_t + \beta_4 Covar_{imt} + \beta_5 Mother_m + \beta_6 Year_t + \varepsilon_{imt}$$

The coefficient of interest, β_1, represents the effect of the revised WIC food package on the outcome of interest. $Covar$ is a vector of covariates representing maternal and child characteristics, and $Mother$ represents maternal fixed effects. The inclusion of fixed effects addresses a fundamental source of confounding.[6] In particular, we may worry that some women are more likely to experience better health outcomes, and that these same women are also more likely to enroll in WIC (e.g., due to intellectual abilities, genetic endowment, or family history). Including maternal fixed effects adjusts for these time-invariant unobserved characteristics (e.g., the variable for maternal race will fall out of the model), although of course no models can account for time-varying unobserved characteristics. Finally, ε represents robust standard errors clustered at the level of the mother to account for correlated observations. Both continuous and binary outcomes were modeled using linear models. This is standard for DID analyses, because of the different interpretation of interaction terms in non-linear models.[7] Coefficients for binary outcomes can therefore be interpreted as the percent change in risk.

DID models rely on the assumption that the slopes (not the levels) in the outcomes during the pre-revision period were similar, commonly known as the "parallel trends assumption." Conceptually speaking, we did not expect that the policy would lead to a time-dependent change in health outcomes (e.g., a month-to-month continual change in diabetes trends among WIC recipients and non-recipients). Rather, we hypothesized a shift in the underlying levels of the outcomes of interest. Moreover, econometrically speaking, this study relies on a single source of variation (i.e., the policy change). Therefore, the analysis is only "identified" to estimate a single causal effect. In other words, from a causal inference perspective, we can estimate a change in trends or a change in levels, but not both.[8]

We tested the parallel trends assumption by graphically comparing the slopes for each outcome among WIC recipients and non-recipients (eFigures 1a and 1b). For all outcomes except preterm birth and gestational diabetes, these graphs demonstrated roughly parallel trends during the pre-revision period.

DID analysis also assumes that there are no other factors that might differentially influence the trends in the outcomes between the treatment and control groups other than the revisions to WIC. While there is no way to test this counterfactual scenario, we examined whether there were changes in the key covariates between the pre- and post-revision periods among WIC recipients that differed from pre-post changes among non-WIC recipients (Table 1). These trends were roughly similar between the two groups. For example, while there were fewer births to Hispanic women during the post-revision period relative to the pre-revision period among WIC recipients, this was paralleled by a similar decline in Hispanic births among non-WIC recipients. While we are unable to test whether there are differences in unobserved characteristics, we nevertheless adjust for the observed characteristics to account for possible confounding.

Finally, we carried out a sensitivity analysis in which we restricted the sample to those women with a high school education or less. This was done because of concerns that more educated non-WIC recipients might not represent an appropriate "control" group for WIC recipients. However, when we examined the parallel trends graphs after restricting the sample in this way, the trends during the pre-revision period were no longer parallel for low-education WIC recipients and low-education non-WIC recipients (eFigures 2a and 2b). It may be that women with low education who do not receive WIC represent a fundamentally different group of women, especially in

California, due to unobserved characteristics like immigration status or other factors. For this reason, the primary analysis for this manuscript was conducted without restricting the education levels of women in the sample.

Secondary Analyses

In addition to the secondary analyses described in the main manuscript, we also conducted a sensitivity analysis in which we included fixed effects for month and year of birth (i.e., 6 years × 12 months = 72 additional indicator variables). This provided a more granular adjustment for possible secular trends. For both maternal and health outcomes, results of these sensitivity analyses were similar to our primary analyses (see eTable 1).

Supplemental References

1. Talge NM, Mudd LM, Sikorskii A, Basso O. United States Birth Weight Reference Corrected For Implausible Gestational Age Estimates. Pediatrics 2014.
2. Baumeister L, Marchi K, Pearl M, Williams R, Braveman P. The validity of information on "race" and "Hispanic ethnicity" in California birth certificate data. Health services research 2000;35:869-83.
3. Dietz PM, Bombard JM, Hutchings YL, et al. Validation of obstetric estimate of gestational age on US birth certificates. Am J Obstet Gynecol 2014;210:335.e1-.e5.
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5. Lain SJ, Hadfield RM, Raynes-Greenow CH, et al. Quality of data in perinatal population health databases: a systematic review. Med Care 2012;50:e7-20.
6. Gunasekara FI, Richardson K, Carter K, Blakely T. Fixed effects analysis of repeated measures data. International Journal of Epidemiology 2013;43:264-9.
7. Karaca-Mandic P, Norton EC, Dowd B. Interaction terms in nonlinear models. Health services research 2012;47:255-74.
8. Lechner M. The estimation of causal effects by difference-in-difference methods. Foundations and Trends in Econometrics 2011;4:165-224.

eTable 1. Effect of revised WIC food package on maternal and infant health outcomes, including control variables for month and year of birth

Maternal Outcomes	**Effect of Revised WIC Package**	**95% CI**
Preeclampsia	-0.60	-0.76, -0.44
Gestational diabetes	-0.060	-0.28, 0.16
Less than recommended gestational weight gain	0.80	0.41, 1.2
More than recommended gestational weight gain	-3.1	-3.6, -2.6
Within recommended gestational weight gain	2.3	1.8, 2.8
Infant Outcomes		
Birth weight, z-score	-0.0082	-0.016, -0.00057
Gestational age at delivery, weeks	0.018	0.0015, 0.034
Preterm birth	0.17	-0.078, 0.42
Appropriate for gestational age	0.92	0.53, 1.3
Small for gestational age	-0.41	-0.68, -0.15
Large for gestational age	-0.51	-0.80, -0.22
Low birth weight	-0.21	-0.42, -0.0059
Very low birth weight	-0.080	-0.16, 0.0040
Longer than expected infant admission at birth	0.0041	-0.30, 0.31
Infant readmitted in 1st year after birth	0.10	-0.43, 0.23

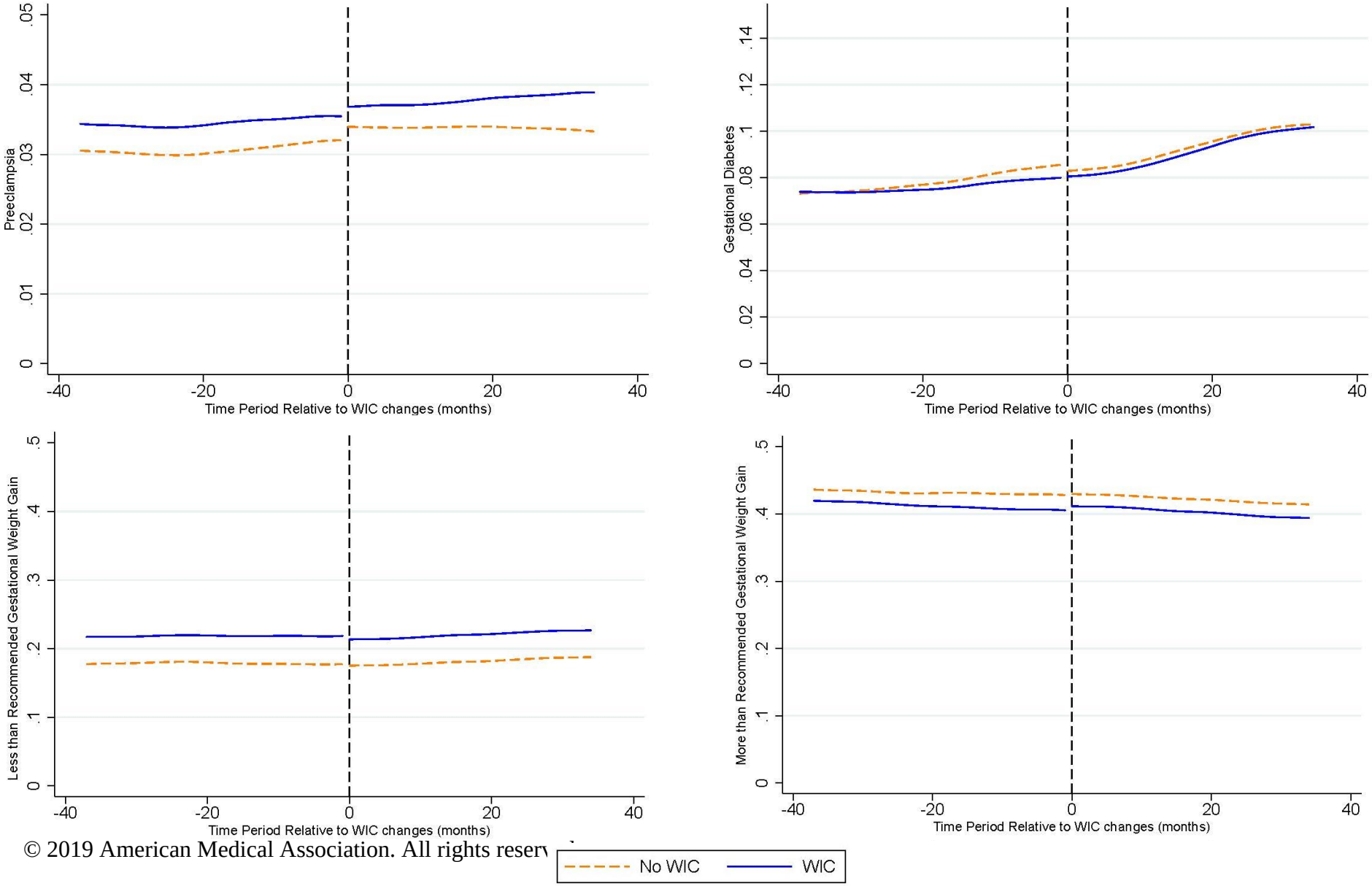
Note: Values above represent the coefficients on the interaction term between WIC receipt and mother giving birth in February 2010 or later. Coefficients for binary outcomes were multiplied by 100 and therefore represent a change in percentage points. Analyses involved multivariable linear models (i.e., linear probability models for binary outcomes) with maternal fixed effects and robust standard errors clustered by mother. Covariates included mother's race, education, age, and parity, infant's gender, and month and year of birth. WIC: Special Supplemental Nutrition Program for Women, Infants, and Children.

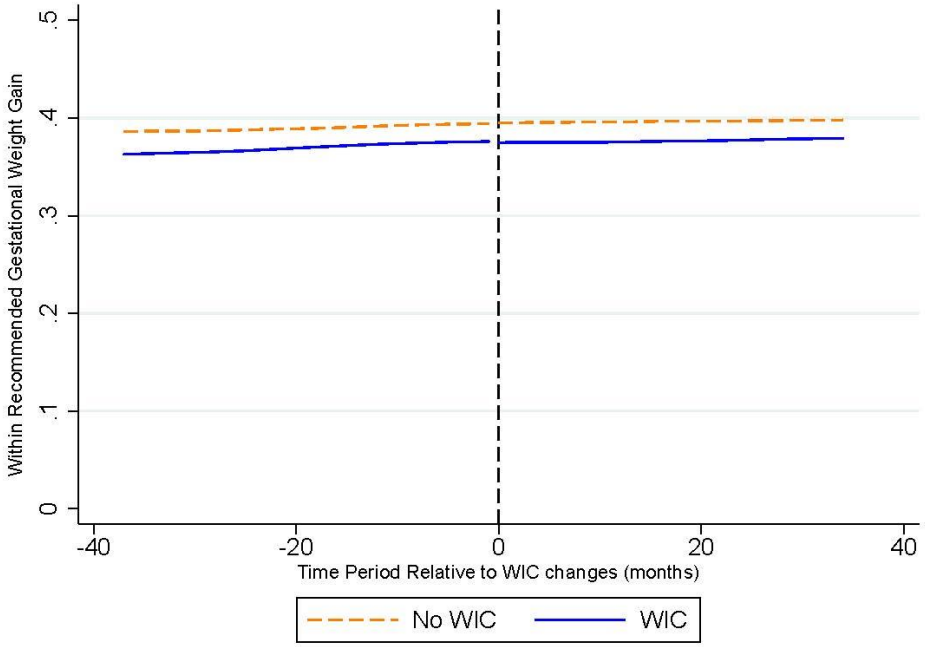
eTable 2. Effect of revised WIC food package on maternal and infant health outcomes, excluding pregnancies that included October 2009

Maternal Outcomes	**Effect of Revised WIC Package**	**95% CI**
Preeclampsia	-0.58	-0.77, -0.39
Gestational diabetes	-0.082	-0.34, 0.17
Less than recommended gestational weight gain	1.1	0.64, 1.5
More than recommended gestational weight gain	-3.3	-3.8, -2.7
Within recommended gestational weight gain	2.2	1.5, 2.8
Infant Outcomes		
Birth weight, z-score	-0.0060	-0.015, 0.0029
Gestational age at delivery, weeks	0.017	-0.0019, 0.036
Preterm birth	0.29	-0.0012, 0.58
Appropriate for gestational age	0.93	0.48, 1.4
Small for gestational age	-0.41	-0.72, -0.099
Large for gestational age	-0.52	-0.86, -0.19
Low birth weight	-0.089	-0.33, 0.15
Very low birth weight	-0.088	-0.19, 0.010
Longer than expected infant admission at birth	0.12	-0.23, 0.48
Infant readmitted in 1st year after birth	0.20	-0.18, 0.58

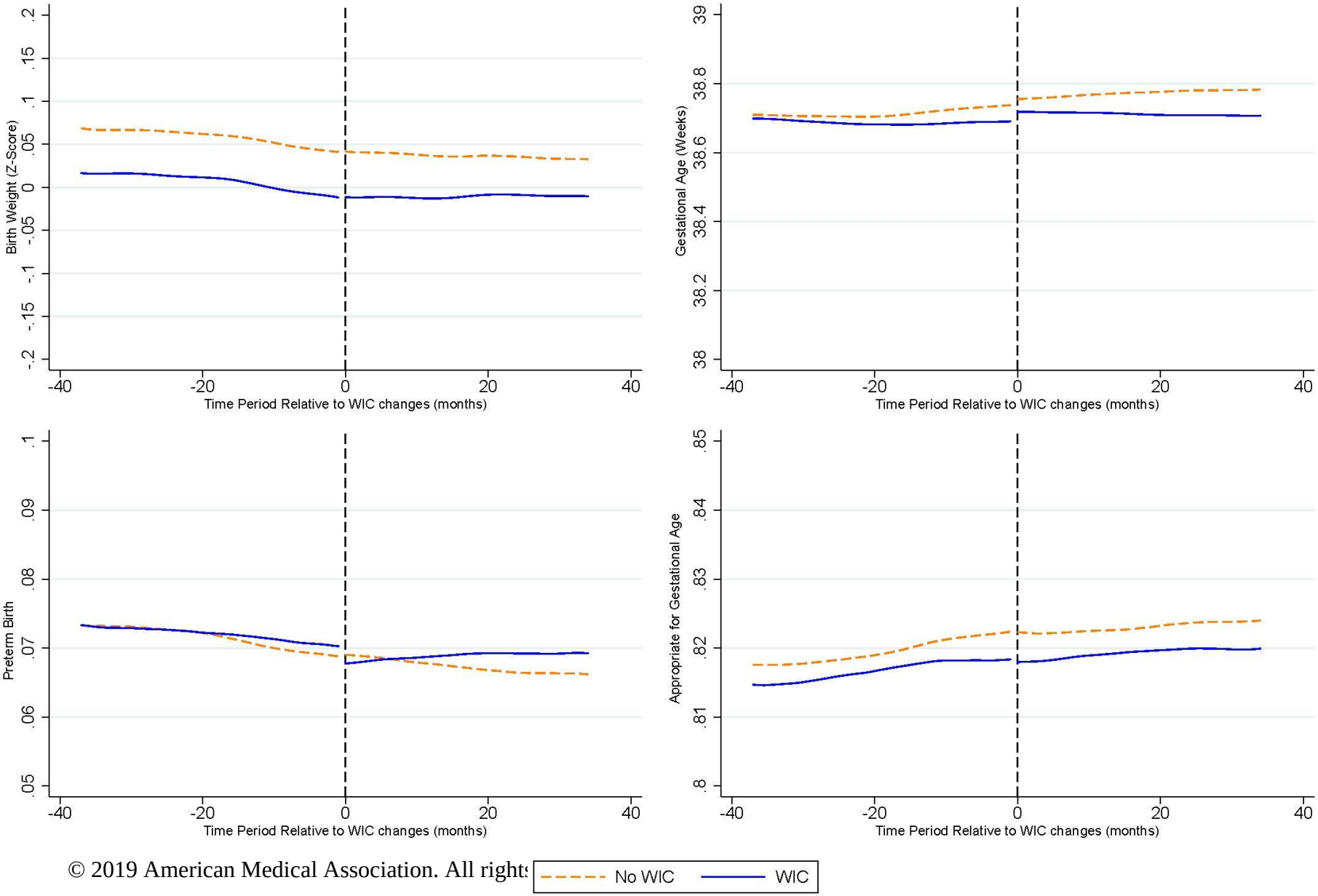
Note: Values above represent the coefficients on the interaction term between WIC receipt and mother giving birth in February 2010 or later. Coefficients for binary outcomes were multiplied by 100 and therefore represent a change in percentage points. Analyses involved multivariable linear models (i.e., linear probability models for binary outcomes) with maternal fixed effects and robust standard errors clustered by mother. Sample excludes mothers whose pregnancy included October 2009. Covariates included mother's race, education, age, and parity, and infant's gender and year of birth. WIC: Special Supplemental Nutrition Program for Women, Infants, and Children.

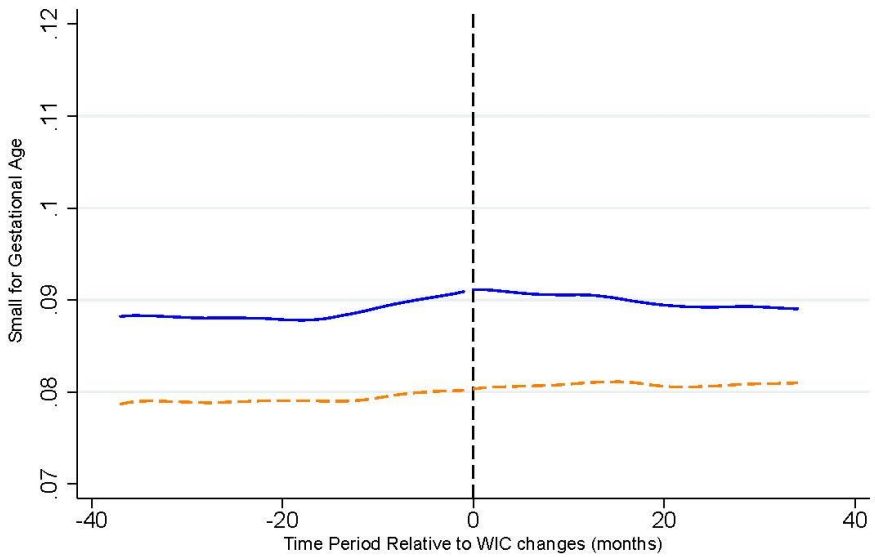
eFigure 1A. Graphical evaluation of parallel trends assumption, maternal outcomes

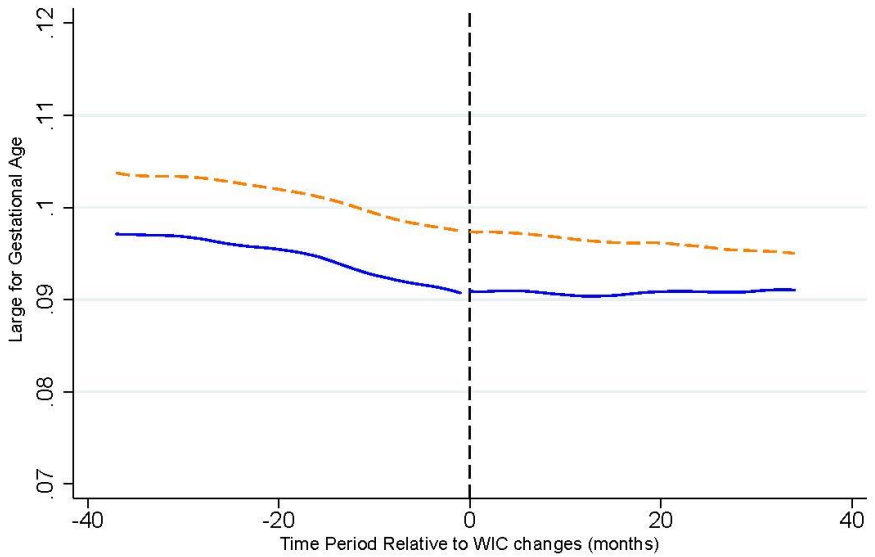


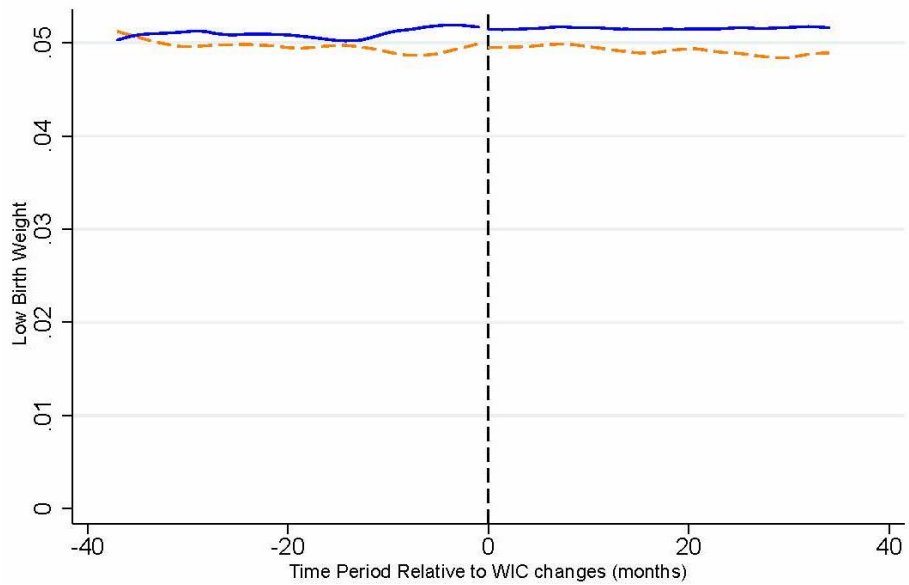


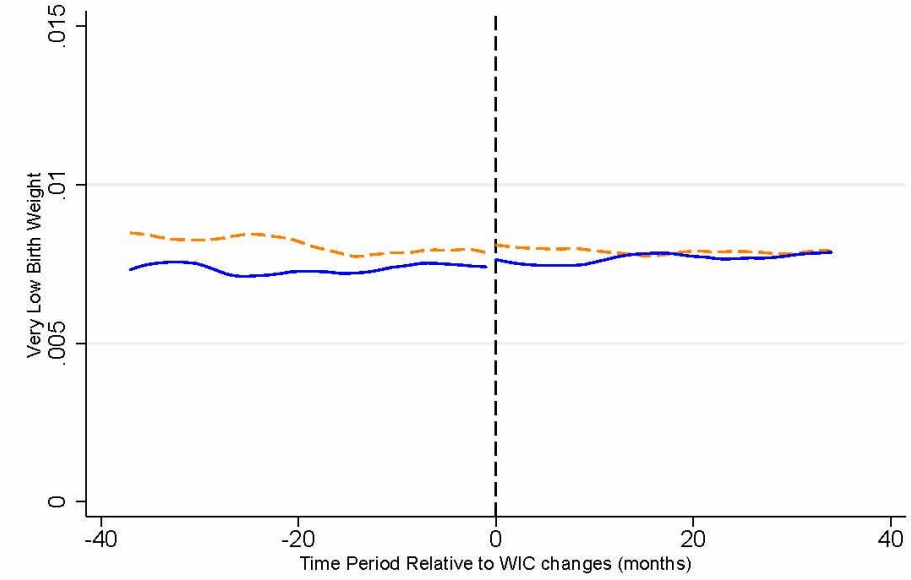
eFigure 1B. Graphical evaluation of parallel trends assumption, infant outcomes

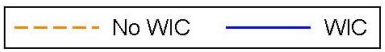


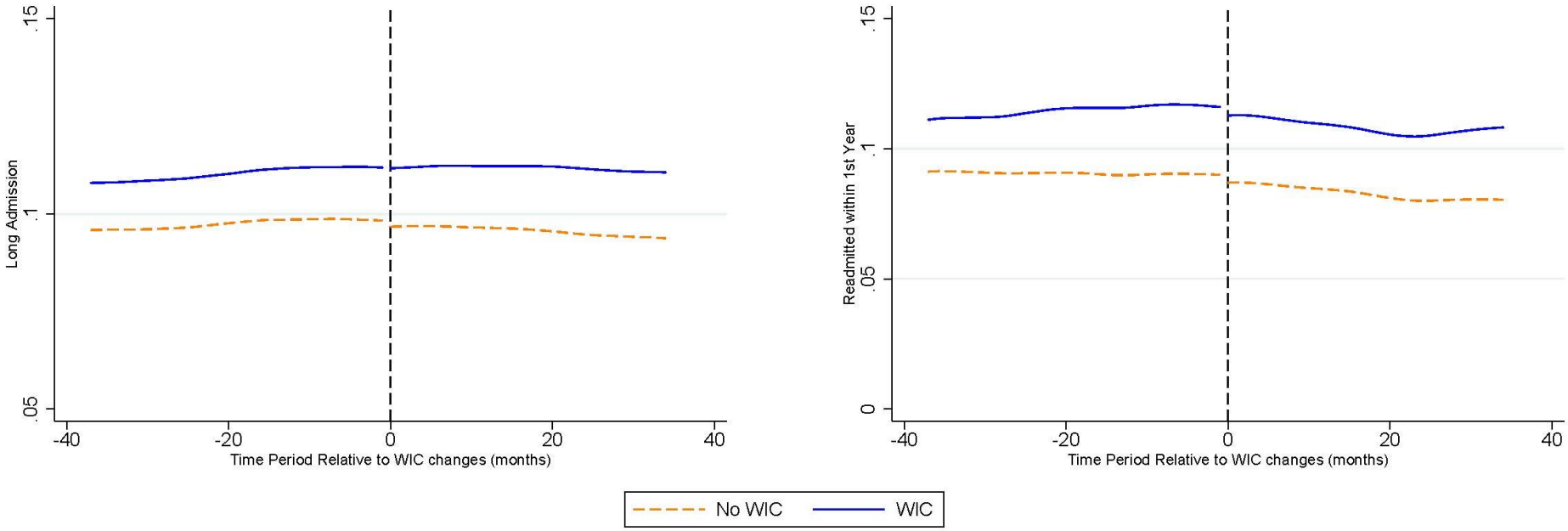




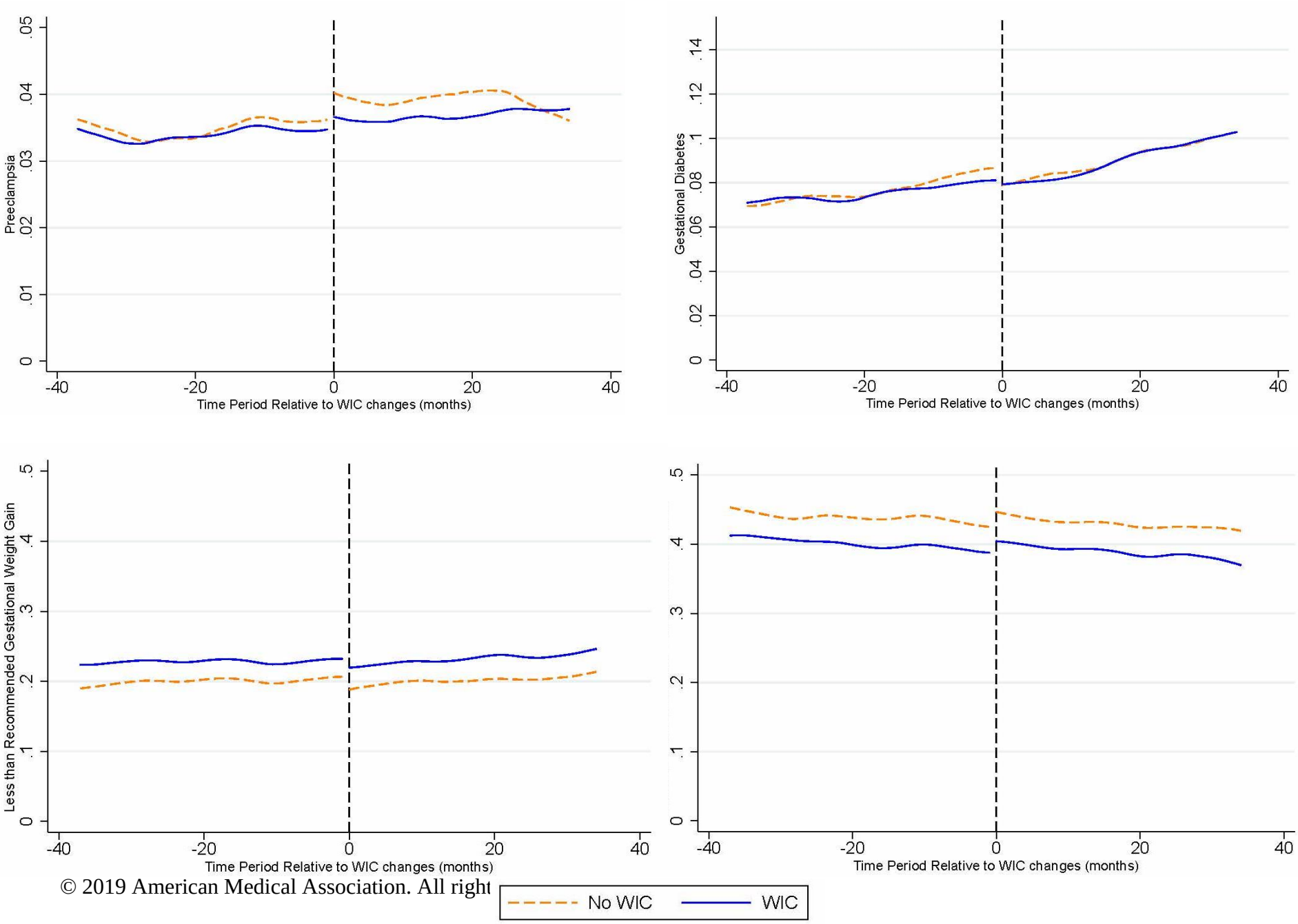


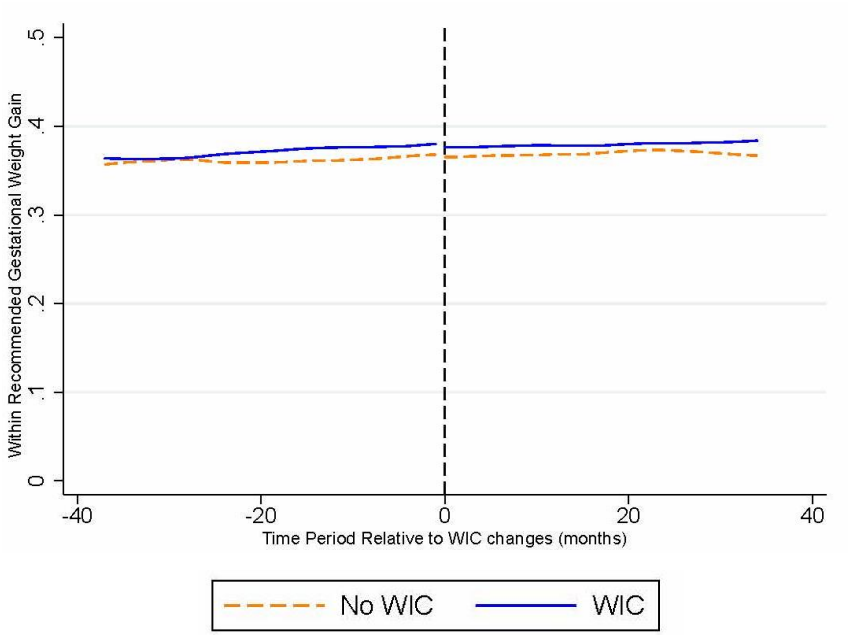






eFigure 2A. Graphical evaluation of parallel trends assumption in low-education sample, maternal outcomes





eFigure 2B. Graphical evaluation of parallel trends assumption in low-education sample, infant outcomes