Improving Community Outcomes for Maternal and Child Health: An Evaluation of the Long-Acting Reversible Contraception Intervention

Master's Thesis

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Abstract

Objectives. Preterm birth (PTB) and low birth weight (LBW) are adverse birth outcomes of critical public health concern. This paper seeks to evaluate a Long Acting Reservable Contraception (LARC) intervention as part of Improving Community Outcomes for Maternal and Child Health (ICO4MCH).

Methods. Aim one used birth certificate data to determine if the intervention contributed to decreased PTB and LBW. Aim two used county-level contraceptive data to determine if the intervention was associated with an increase in LARC methods.

Results. Babies born in ICO4MCH counties had decreased odds of PTB but not LBW post implementation. Health departments in most but not all ICO4MCH counties had increased uptake of LARC methods post intervention.

Conclusions. Findings from this evaluation lend support to LARC to reduce PTB.

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Introduction

Preterm and Low Birth Weight Birth

Preterm birth (PTB) and low birth weight (LBW) are birth outcomes of critical public health concern and are leading causes of infant mortality in the United States (U.S.) (1,2). In 2017, about 17% of all infant deaths in the U.S. could be attributed to PTB, defined as the birth of an infant prior to 37 weeks gestation, and LBW, defined as the birth of an infant at a weight of less than 2500 grams (1,2). These adverse birth outcomes also impact surviving infants and families and can negatively impact a family's long term financial and emotional wellbeing (3–5). Preterm and low birth weight infants can have problems with immaturity in their organs and higher incidence of intellectual disabilities, cerebral palsy, and impairments in hearing and vision throughout the life course (6–8). There is also evidence to suggest that infants born preterm or low birth weight are more likely to experience significant mental health problems and report lower overall functioning in adulthood when compared to infants born on time or at an adequate birth weight (9,10).

In the U.S. in 2018, the average PTB rate was 9.8% and the average LBW rate was 8.2% (**Table 1**). Compared to other countries with similar economic profiles, the U.S. has considerably higher rates of PTB and LBW (11–13). Moreover, there are significant disparities in the incidence of PTB and LBW by race and ethnicity in the U.S., with Black infants almost 1.5 - 2 times as likely to experience these adverse birth outcomes (14–16). In North Carolina, the average rate of PTB and LBW is slightly greater than in the national population, with 9.3% of infants being delivered at a low birth weight and 10.4% being delivered preterm (16). Like the rest of the U.S., racial disparities in PTB and LBW births are stark in North Carolina.

Table 1. LBW and PTB Rates per 1000 Live Births by Race-Ethnicity in the U.S. and North Carolina

	U.S.		N.C.	
	PTB*	LBW**	PTB*	LBW**
Overall	9.8	8.2	10.4	9.3
White	9.0	7.0	9.3	7.6
Black	13.6	13.7	13.8	14.2
American Indian	11.3	8.1	11.9	11.8
Asian	8.7	8.5	8.6	8.9
Hispanic	9.4	7.4	8.9	7.5

*PTB rates reflect data from 2016-2018
**LBW rates reflect data from 2015-2017
Note: data are from March of Dimes Peristats Database **(16)**

Risk and protective factors for PTB and LBW occur both prior to and during pregnancy and include a broad range of interwoven factors. Haas et al. (21) found that demographic characteristics and pre-pregnancy risk factors together account for more than half of all risk for preterm delivery (13% and 39.8%, respectively). Risk factors of both PTB and LBW include: experiencing racism, high stress levels of the mother, low socioeconomic status (SES), and smoking during or before pregnancy (14,15,17–24). Important protective factors for PTB and LBW include: living in an area with access to social support resources, access to regular medical care and medical insurance, access to high-quality prenatal care, and access to effective contraceptive methods (24–30).

Long Acting Reversible Contraception

Access to highly effective contraceptives for women who want them, such as long-acting reversible contraceptives (LARC), has been found to be an important protective factor against PTB and LBW (26,29,31,32). LARC contraceptive methods include intra-uterine devices (IUDs), such as Mirena or Paraguard, and implants (Nexplanon). Access to contraceptive methods may reduce PTB and LBW by providing women control of their reproductive life plan and allowing them to intentionally increase birth spacing and prevent unintended pregnancy (33–37). Access to highly effective contractive methods is particularly important for women who have recently experienced an adverse birth outcome like PTB, as they are at increased risk of having subsequent preterm births. However, increased birth spacing may reduce this risk in future births (35,37). LARC as a contraceptive method is particularly effective for increasing birth spacing and reducing unintended pregnancy; LARC methods are over 99% effective, requires no daily or monthly maintenance, and can be removed when and if a woman desires to become pregnant (38,39).

While short interpregnancy intervals (IPI) or birth spacing, especially spacing of less than six months, may be associated with increased odds of PTB and LBW, no clear mechanism has yet to be identified. Debate exists as to whether the apparent association between IPI and adverse birth outcomes is due to uncontrolled confounding characteristics (33,34). IPI may impact birth outcomes through folate depletion, incomplete uterine healing from a previous caesarean delivery, vertical transmission of infections, or cervical insufficiency (34). Unintended pregnancy may increase PTB and LBW through increased stress, delayed initiation of prenatal care, or delayed cessation of higher risk behaviors that impact pregnancy outcomes (36,40–42) However, similar to IPI, few studies are able to control for the various confounding characteristics that may be associated with PTB and LBW and some question exists as to whether the association between adverse birth outcomes and unintended pregnancy may be due to confounders (36).

IUDs and implants have been available in the U.S. for many decades, but the uptake of LARC as a method of contraception has increased rapidly among women in the last fifteen years (43–45). Despite increased utilization of, and desire for, LARC, several barriers exist at the clinic and provider level that can prolong or prevent women from accessing LARC as a contraceptive method. One such barrier is when clinic protocols or practices do not allow LARC insertion the same day the woman seeks it. When same day LARC insertion is not available for a woman, she must return for another visit to receive her LARC, which results in more time and potentially money as well as a risk for unintended pregnancy during the wait time (46–48). Several studies have found that women who have access to LARC insertion the same day they request it are more likely to receive their intended contraceptive method and that delaying insertion results in decreased utilization of these contraceptive methods (46,48). Other barriers to same day LARC insertion include clinician and patient misconceptions about LARC and lack of providers experienced in LARC insertion and removal (47,49–51). The utility of LARC as a safe and effective contraceptive method that can prevent unintended pregnancies and increase birth spacing and the general increase in prevalence and acceptance of LARC as a contraceptive method over time has increased interest in same-day LARC insertion provisions as a potential public health prevention to reduce PTB and LBW.

Improving Community Outcomes for Maternal and Child Health

To address the high rates of PTB, LBW, and infant mortality in North Carolina, in 2015 the North Carolina General Assembly allotted $2,500,000 (session law-241) in yearly funding to be distributed to local health departments (LHD) to implement Evidence-based strategies (EBS). The resulting program, Improving Outcomes for Maternal and Child Health (ICO4MCH), is an academic-practice partnership between the North Carolina Division of Public Health (DPH), the University of North Carolina at Chapel Hill Gillings School of Public Health, and LHDs receiving funding for ICO4MCH (52). The ICO4MCH program has three aims: 1) improving birth outcomes, 2) reducing infant mortality, and 3) improving child health ages 0-5.

ICO4MCH began in January of 2016 with a planning period lasting until June 2016. From January - June 2016, planning funds were allocated to LHDs to develop community action teams, examine which EBSs were most appropriate for their specific context, and prepare applications for implementation funding to DPH (52). In total, 63 LHDs received planning dollars, 56 were eligible for full ICO4MCH funding, and five grantees representing 13 counties as individual counties or as collaboratives received implementation funding for two years beginning in June 2016. Funding varied by grantee and ranged from $350,000-500,000 annually per grantee (52).

Each funded county or collaborative selected at least one EBS to implement for each of the three aims: improve birth outcomes, reduce infant mortality, and improve child health for children aged 0-5. The two EBSs aimed at reducing infant mortality were

Tobacco Cessation and Prevention and Ten Steps for Successful Breastfeeding. The three EBSs focused on improving child health for children aged 0-5 were Positive Parenting Program (Triple P), Family Connects, and Clinical Efforts Against Secondhand Smoke Exposure (CEASE). All grantees implemented the same EBS aimed at improving birth outcomes, called Long-Acting Reversible Contraception (LARC).

As part of the ICO4MCH LARC EBS, the LHD worked collaboratively with internal and external partners and with guidance from community action and implementation teams to implement the following: 1) Outreach and education to men and women of childbearing age about counselling and family planning methods, including LARC; 2) Outreach and training for public and private health care providers on LARC insertion and removal, and various other education topics (i.e. informed consent); 3) Improve access to same-day LARC insertion by increasing the number of clinics/providers that have a same-day insertion policy and practice and; 4) Identify and address barriers to same-day LARC insertion.

As described above, one important area of focus during the first two years of program implementation was to increase access to LARC for women who wanted LARC. To do this, each collaborative worked with external clinic partners to improve access to same-day LARC insertion within the LHD by working towards developing same-day LARC insertion policies and practice. Same day LARC insertion policies indicate intentional incorporation of same day LARC insertion practice into a LHD and requires coordination with administration and providers. Same day LARC insertion practice was assessed to determine how often a woman requesting a LARC could receive LARC on the same day at any period of time throughout the quarter. Practice was measured as a

LHDs ability to “never”, “sometimes,” or “always” provide LARC insertion to clients on the same day it was requested.

The overarching aim of this analysis is to: examine to what extent the LARC EBS implemented as part of the ICO4MCH program was associated with improved birth outcomes in 13 North Carolina counties receiving funding. Our analysis has two sub-aims. Aim one was to determine if trends in birth outcomes, specifically PTB and LBW, improved after implementation of ICO4MCH in ICO4MCH counties compared to counties in NC where ICO4MCH was not implemented. In aim one we hypothesized the trend in the odds of babies born preterm or low birth weight in ICO4MCH counties would improve at a faster trajectory than trends in non-ICO4MCH counties. The second aim was to investigate whether trends in LARC utilization increased more rapidly after implementation of the ICO4MCH intervention in LHDs in ICO4MCH counties compared to LHDs in North Carolina counties without ICO4MCH. In aim two we hypothesized that the ICO4MCH LARC intervention would increase access to LARC and other family planning methods, thereby increasing the number of women adopting LARC compared to LHDs in NC without ICO4MCH.

Methods

Study Design and Setting

We used a quasi-experimental design to evaluate the contribution of ICO4MCH on Aim 1) PTB and LBW and Aim 2) LARC Utilization. Aim one was designed as a retrospective cohort analysis and aim two was designed as a retrospective cross-sectional analysis.

Selection of Treatment and Comparator Groups

To test our two hypotheses, we sought to define a treatment and comparison group of North Carolina counties to use for analysis of both aims **(figure 1).** The treatment group for this evaluation included counties which ultimately received full ICO4MCH funding beginning in June 2016 (N=13 counties). Treatment counties consisted of two counties which received funding independently and 11 remaining counties that formed three collaboratives. In total, ICO4MCH funded five lead LHDs, called "grantees", which consisted of 13 total counties and made up the treatment group for this analysis.

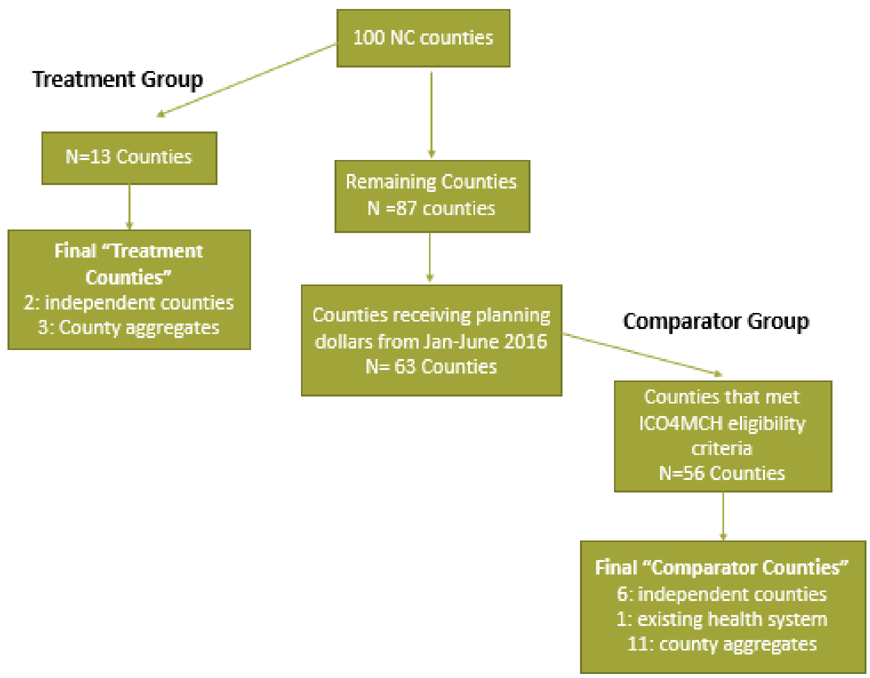
In order to target the ICO4MCH program to areas in highest need with a substantial portion of births, the DPH set certain guidelines for county eligibility for ICO4MCH funding. A county or combination of counties was eligible for the funding if there were at least 1,000 births in 2014 and at least one of the following criteria were met:

- Combined infant mortality rate of 10.8 or higher per 1,000 live births and 20 or more infant deaths in 2012-2014
- An infant mortality disparity ratio (comparing Black non-Hispanic to White non-Hispanic) of 2.4 or higher in 2012-2014
- Percent of children <18 years in poverty 37.7% or greater based on 2013 data
- Percent of children <18 years of age is 11.1% of higher based on 2009-2013 combined American Community Survey data.

We aimed to establish a comparison group of North Carolina counties that would have a similar likelihood of receiving ICO4MCH funding as the ICO4MCH funded counties.

We therefore only included counties in the comparator group that would have been eligible for ICO4MCH but either did not apply or were not funded. Among the 100 North Carolina counties, only counties receiving planning money (n=63) and that met ICO4MCH eligibility criteria independently or as collaboratives (n=56) were selected as comparator counties. Among these 56 counties, six counties independently met eligibility criteria for the program and were included in the comparison group as independent counties. There was also one existing county health district, which included eight counties, that met criteria and was included in this analysis as a comparator group. Finally, eleven county aggregates were created where combinations of counties met eligibility criteria and were included as collaboratives in the comparison group. Overall, the comparator group thus included births from 18 groups or independent counties, which consisted of 56 total counties. In total, data from 69 of 100 North Carolina counties were included in either a treatment or comparison groups. These defined groups were used to analyze both aim one and aim two.

Figure 1. Treatment and Comparator Groups



Aim One: Analysis of ICO4MCH Impact on Birth Outcomes

Sample

To investigate the first aim of this evaluation, all births from January 1, 2013 through December 31, 2018 (n=707,933) were from the North Carolina Consolidated Linked Birth File or Babylove file and were eligible for this analysis. The Babylove file integrates live birth certificate data with linked data from a variety of other public health data sources via a probabilistic linkage. The resulting file is comprised of eight sections: Birth file, Newborn Medicaid, Mother Medicaid, Newborn Medicaid Costs, Special Supplemental Nutrition Program for Women, Infants and Children (WIC), Infant Death, Hospital Discharge Newborn, and Hospital Discharge Maternal.

Multiple gestations (n=24,803) and births where plurality was unknown (n=2) were excluded from our analysis. Additionally, 398 births were excluded from the analysis because of implausible values of gestational age, birthweight, or maternal age (53). After these exclusions, 682,730 births from 100 NC counties were eligible for the analysis. The treatment group for the final analysis consisted of births that occurred in ICO4MCH counties (N=13 counties; N=181,350 births). The comparison group consisted of births that occurred in comparator counties (N=56 counties; N=300,619 births). In total, there were 481,969 births between 2013-2018 in the 69 North Carolina counties included in this analysis.

Measures

The primary outcomes in this analysis were PTB and LBW. PTB was defined using the obstetric estimate of gestation on the child's birth certificate and LBW was defined using the birth weight variable from the child's birth certificate. Both variables were then dichotomized into groups based on whether each outcome was present. Preterm birth was defined as a gestational age of <37 weeks and all eligible infants with a gestational age of <37 weeks were coded as a PTB. LBW was defined as a birth weight of <2500 grams and all eligible infants with a birth weight of <2500 were coded as LBW.

The evaluation was designed as a retrospective cohort study with an ecological exposure, ICO4MCH funding for the LARC EBS. Thus, the main exposure was whether a mother resided in an ICO4MCH/treatment county versus a comparator county. County of residence of the mother was defined using the county of residence on the child's birth certificate. The mother's residence was then dichotomized into residence in a treatment or control county.

Confounders were selected for each outcome based on a literature review. Maternal age, smoking status, maternal education, Medicaid status, maternal race/ethnicity, pre-pregnancy body mass index (BMI), child's sex, previous preterm birth, parity, pregnancy weight gain, rurality, maternal diabetes, maternal hypertension, Women, Infants, and Children (WIC) enrollment, and concurrent programming were included as covariates for both outcomes (17,22,24,25,27,30,54–56). All adjusted models also included an adjustment for county aggregate (i.e. the groups outlined in the selection of treatment and comparator group section) to address the fact that observations are nested within county aggregates so we cannot assume that they are independent. A detailed description of all measures is included in the appendix (**table 7**).

Analysis

We began by tabulating pre-selected maternal and child characteristics by maternal residence in treatment or comparator counties (**table 2**). A Pearson chi-squared test was calculated to determine if treatment and comparator groups differed by these pre-selected characteristics. We then conducted a comparative interrupted time series difference in difference analysis for two outcomes PTB and LBW using logistic regression. In particular, we were interested in estimating the three-way interaction term for maternal residence in a treatment county, birth before or after the intervention, and continuous time in years in order to determine if there was a change in log odds of each outcome over time in the intervention group after the intervention (June 1, 2017) that was not seen over time in the comparator group after June 1, 2017. (57,58) **(table 3).** Unadjusted and adjusted models were conducted for each outcome separately. Analyses were stratified by maternal race/ethnicity for both outcomes to examine whether the impact of ICO4MCH on birth outcomes differed by race/ethnicity.

The logistic regression models were fit using generalized estimating equations (GEE) to account for correlation between siblings. Complete information on siblings was not available. Where possible, we matched siblings to each other via a fuzzy match approach, using maternal date of birth, maternal location of birth (state and county), maternal race/ethnicity, parity, and child's month and year of birth. In some cases, we were unable to identify which children were siblings (i.e. there might be more than one mother/child pair with the same characteristics). In these cases, it was not possible to match siblings and these children were considered independent observations.

While the ICO4MCH counties began to receive implementation funding in June of 2016, it was posited that it would take the counties a year to hire staff and fully implement the EBS according to the implementation science framework. In addition, we also expected there to be a lag between outreach, education, family planning services and impact on birth outcomes. Therefore, the intervention date was set a priori to June 1, 2017 in our primary regression models anticipating that this is when we might start to see an impact on our outcomes.

Because this difference in difference model assumes the time trends in the treatment and control groups are parallel prior to the start of the implementation of intervention (i.e. June 1, 2016), an analysis of trends prior to June 1, 2016 was also conducted. We calculated the log odds of the outcome during each month separately for the treatment and comparator groups. To assess the parallel trend assumption, we carried out a local weighted regression (lowess) of the log odds of the outcome on month-year of birth for the treatment and comparator groups restricting to prior to June 1, 2016. We then generated and visually inspected graphs to look at trends over time in the treatment and comparator groups. The interaction between treatment and time prior to the intervention was also formally tested by running logistic regression models for each outcome for the time-period prior to the intervention period (January 1, 2013- June 1, 2016) using likelihood ratio tests. The parallel trends interaction test did not account for siblings using GEE (unlike the main model) as likelihood ratio tests cannot be conducted with a GEE model.

Equation for the unadjusted difference in difference model

$$logit\big(P(Y=1)\big) = \beta_0 + \beta_1 Treatment + \beta_2 Post + \beta_3 Time + \beta_4 Treatment * Post + \beta_5 Treatment * Time + \beta_6 Post * Time + \beta_7 Treatment * Post * Time$$

Aim Two: Analysis of ICO4MCH Impact on LARC Utilization

Sample

To investigate whether ICO4MCH funding increased utilization of LARC methods in LHDs, we obtained data on reported contraceptive methods from the Family Planning Branch of the North Carolina Division of Public Health. This dataset included county-level data on contraceptive method choice for female-identifying clients who received services at each individual LHD or health system between 2013-2019 in all treatment and comparison counties (n=400,475). Data were collapsed into treatment (n=113,906) and comparison groups (n=286,569) using the same method outlined in the treatment and comparator group section. The data collection method for this data changed in 2018. This change was to improve data quality. Between 2013-2017 data was obtained by the Family Planning Branch of the North Carolina Division of Public Health from the Health Information System Family Planning Annual Reports (HIS). Data from 2018 and 2019 were obtained from the LHDs electronic medical records.

Despite efforts to improve data quality, there were of female-identifying clients with “unknown” contraceptive method data (n=63,300). Data was unavailable for two years (2016-2017) for one comparator county included in this analysis. Data for these two years were coded as missing and this comparator county was included in the models. Data from 2017 was reported possibly of poor quality as it was a transition year for LHDs to a new data collection system. For 2017, data for 6 individual counties was reported as missing ‘one or more than one months’ worth of reporting data. Data for the other months were still provided and used in this analysis. For these groups, data was likely undercounted. The reported missing data was from both comparator (n=5) and treatment groups (n=2 counties).

If a county was part of a preexisting health system, contraceptive data were only available as an aggregate for the entire system between 2013-2017. Because counties were collapsed into existing or generated groups and these groups almost always overlapped with the existing health systems, data analysis was not meaningfully impacted by this change in data collection methods.

All county groups were included in the analysis as outlined in the selection of treatment and comparator group section, with one exception. For one treatment group (which included five counties) we were unable to include one of these five counties. Because this county is part of an existing health system in which the other 2 counties in that health system did not receive ICO4MCH funding, we had no way of extracting the individual county data from the health system to include the county's data in the treatment group. We also could not exclude the county data from analysis as data was only available aggregated for the entire health system from 2013-2017. Instead, we included this one treatment county with its health system aggregate (in a comparator group) for all years (including 2017 and 2018). All other aggregate health system data between 2013-2017 was coded with the correct exposure group for all years.

Measure

The primary outcome in this analysis was LARC utilization. LARC utilization was defined as the percentage of total female clients who chose a LARC for their contraceptive method each year. This outcome was defined using three variables: the number of clients who used an implant as a contraceptive method, the number of clients who used an IUD as a contraceptive method, and the total female-identifying clients. The total-female identifying clients included all clients, even if they were reported as having an "unknown" contraceptive method. For each year (2013-2019) total female clients who used IUDs and implants were summed and divided by the total number of female clients during that year.

This study was designed as a retrospective cross-sectional analysis with an ecological exposure. Therefore, the main exposure was health department (in a particular county) in which a female client received health services. The county in which services were received was first grouped into treatment and comparison groups outlined in the treatment and comparison group section. They were then dichotomized between whether a woman received services in an ICO4MCH/treatment county versus a comparator county.

Analysis

Because this difference in difference model assumes the time trends in the treatment and control groups are parallel prior to the start of the implementation of intervention (2017), an analysis of trends in LARC utilization between January 1, 2013 – January 1, 2016 was also conducted. We generated logistic regression models for the time-period prior to the intervention for treatment and comparator counties separately and ran a likelihood ratio test to compare trends.

We first tabulated our outcome by exposure status and year **(table 4).** We then conducted a difference in difference time series analysis for our outcome, LARC utilization, using logistic regression. We ran one crude logistic regression model in which all five ICO4MCH treatment aggregates were included (model 1) and one crude logistic regression model in which we excluded one treatment group due to different trends in that group compared to others in the treatment group (model 2) **(table 5)**. We were interested in estimating the interaction term for maternal residence in a treatment county and birth before or after the intervention to examine if there was a difference in the prevalence of LARC utilization in the treatment group after January 1, 2017 compared to the prevalence of LARC utilization in the comparator group after January 1, 2017. The intervention date was set a priori to January 2017 for two reasons. One, data were only available on a yearly basis and thus we could not set an intervention date at a mid-year point. Two, while the ICO4MCH counties began to receive implementation funding in

June of 2016, we posited that it would take the counties at least six months to a year to hire staff and fully implement the EBS.

Finally, we generated predictive probabilities using the margins command in Stata for any model in which we saw a meaningful interaction to determine if the change seen among treatment counties was different than the change seen in comparator counties (**table 6).**

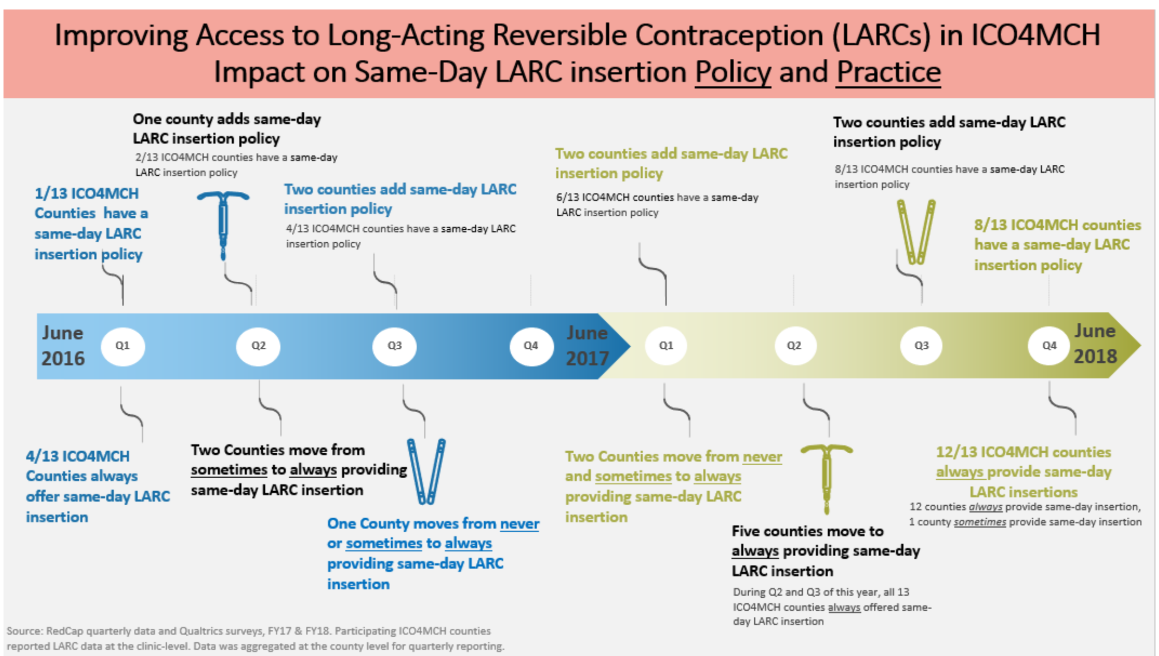
Results

Results of the ICO4MCH Program

Grantees held trainings for LHD staff and partners external to the LHD on IUD and implant insertion and removal, tiered counselling, motivational interviewing, LARC reimbursement, and various other topics related to reproductive health. In year one, the collaboratives trained a total of 246 LHD staff and 87 staff external health department. In year two, the collaboratives trained 268 LHD staff and 98 staff external to the health department. Over the course of two years, grantees provided outreach and education to over 20,000 men and women of childbearing age.

Grantees also worked to increase access to same day LARC insertion. A same day LARC insertion policy was defined as a written, documented policy of same-day LARC insertion practice in a LHD. Same day LARC insertion policies indicate intentional incorporation of same day LARC insertion practice into a LHD and requires coordination with administration and providers. In quarter one of implementation, one of the thirteen ICO4MCH counties had a same-day LARC insertion policy. By the end of year two, eight of the thirteen counties had a same day LARC insertion policy. The presence of a policy, however, does not always mean that women always receive a LARC on the same day they requested it. Therefore, we also collected data on how often same day insertion was offered in practice on average. Data on same day LARC insertion practice was defined as a LHDs ability to "never", "sometimes," or "always" provide same-day LARC insertion to clients. In quarter one, four of the thirteen counties always offered same-day LARC insertion, six of the thirteen sometimes offered same-day LARC insertion, and three never offered same-day LARC insertion. By the end of year two, twelve of the thirteen counties always offered same-day LARC insertion and one county sometimes offered same-day IUD and implant insertion. **Figure 2** displays ICO4MCH treatment counties' progress in their same day LARC insertion practice and policy work from June 2016-June 2018.

Figure 2. Progress in Same-day LARC Insertion Policy and Practice



Results of Aim One: ICO4MCH Impact on Birth Outcomes

After exclusions of births with multiple gestations, unknown plurality, or implausible values of gestational age, birthweight, or maternal age, there were 481,969 births between 2013-2018 in the 69 North Carolina counties included in this analysis. The prevalence of PTB and LBW in our sample was 8.1% and 7.1% respectively. Most women were between the ages of 20-34 (78.4%), had obtained some college or graduated with a bachelors or an advanced degree (63.4%), and resided in an urban area (83.6%). More than half of women in the sample identified as White, 22.6% identified as Black, 15.1% identified as Hispanic, 4.3% identified as Asian, 3.3% identified as multiracial, and 1.5% identified as American Indian or Alaskan Native. Over half of the women were enrolled in Medicaid and 42.5% were enrolled in WIC.

Mothers in ICO4MCH counties differed from mothers in control counties in several key risk and protective factors of PTB and LBW. Women in ICO4MCH counties were older and were more likely to be Black, American Indian, Asian, or Hispanic. Women in ICO4MCH were also less likely to have Medicaid and WIC, less likely to smoke and had higher education.

Preterm Birth

The parallel trends assumption was met for both adjusted models of PTB (LR ChiSq(1)= 0.09, P= 0.77) and LBW (LR ChiSq(1)=0.09, P=.77). Prior to June 1, 2017, we observed no interaction between county of residence and continuous time (β= 0.00, [95% CI: -0.02, 0.02]). However, the three-way interaction term, which tested the interaction between intervention, continuous time and county of residence, was statistically significant in the adjusted model of preterm birth (β= -0.13, [95% CI: -0.22, -0.03]) (**Figure 3**). Because the interaction between treatment and continuous time is zero in this analysis, we can interpret the three-way interaction as the difference between the time slope in the treatment counties after the intervention compared to the time slope in the comparator counties after the intervention. Therefore, our findings indicate that there was a significant difference in the trends over time in preterm birth in treatment counties vs comparator counties after June 1, 2017. When the adjusted PTB model was stratified by race/ethnicity of the mother, the interaction between time, residence in a treatment county and birth before or after the intervention period were not statistically significant for Non-Hispanic Black/African American (β= -0.09, [95% CI: -0.27, 0.08]) or Hispanic (β= -0.11, [95% CI: -0.36, 0.14]) women. However, among Non-Hispanic White women, this interaction was statistically significant (β= -0.20, [95% CI: -0.35, -0.04]). Together, these findings indicate that the reduction seen in preterm birth over time post June 1, 2017 in ICO4MCH funded counties but not in comparator counties in the full model was largely driven by changes in the White population. (**Figures 4-6**).

Low Birth Weight

We did not see evidence of a three-way interaction between intervention, continuous time and county of residence in our adjusted LBW model (β= -0.02, [95% CI: -0.12, 0.08]) **(figure 7)**. This indicates that there was not a significant difference in the trends over time in LBW in treatment counties vs comparator counties after June 1, 2017. No interaction in LBW by race/ethnicity was detected in stratified models.

Results of Aim Two: ICO4MCH Impact on LARC Utilization

In total, the contraceptive method choice of 400,475 female-identifying clients were included in this analysis. Among the entire sample, 11.3% of female-identifying clients chose a LARC as their contraceptive method in 2013 whereas 20.0% chose a LARC as their contraceptive method in 2019.

The parallel trends assumption was met for both model 1 (LR ChiSq(3)=1.61, P=0.66) and model 2 (LR ChiSq(3)= 2.30, P=.51). The interaction term for residence in a treatment county and contraceptive method choice before or after the intervention period (January 1, 2017) was not statistically significant in model 1 (β= 2.94, [95% CI: -0.53, 6.41]). However, there was a significant change in prevalence of LARC utilization after January 1, 2017 in model 2 (β= 6.35, [95% CI: 2.77, 9.94]). These findings indicate that the change in the prevalence of LARC utilization in ICO4MCH counties after the intervention date (January 1, 2017) was significantly different than the change in percent of LARC utilization in comparator counties after the intervention date for four out of five ICO4MCH counties. The generated predictive probabilities calculated for model 2 (**table 6)** indicate that**,** among treatment counties, the intervention period (2017-2019) and non-intervention period (2013-2016) differed significantly in the prevalence of LARC utilization by 10.62%. The observed increase in LARC utilization among women between the two periods (2013-2016 and 2017-2019) was also seen in control counties and was also statistically significant at 4.27%. However, the increase of LARC utilization in treatment counties was significantly larger than the increase in control counties by 6.35%. Therefore, we observed an increase in the intervention period among treatment counties that was significantly greater than the observed increase in the intervention period among the control counties.

Discussion

As hypothesized, we saw a statistically significant decrease in preterm birth in treatment counties over time after June 1, 2017 but did not see a similar decrease in preterm birth in comparator counties after June 1, 2017. We conclude that the ICO4MCH intervention was associated with a decrease in preterm birth in ICO4MCH counties. Additional models stratified by race-ethnicity for the PTB model (Non-Hispanic-White, Non-Hispanic Black, and Hispanic) indicated that the intervention was associated with a significant decrease in preterm birth among Non-Hispanic White mothers, but not among Non-Hispanic Black or Hispanic mothers. However, counter to our hypothesis, we did not observe a statistically significant decrease in LBW in treatment counties over time after June 1, 2017 compared to LBW in control counties over time after June 1, 2017.

Finally, we also found that the LARC EBS led to an increase in LARC utilization in all but one ICO4MCH counties compared to comparators after the implementation of the ICO4MCH intervention. This observation was counter to our hypothesis, as we expected LARC utilization to increase in all ICO4MCH counties after implementation of the EBS. The lack of increased LARC utilization in this one county was likely due to repeated natural disaster events that disproportionately impacted this county compared to others in ICO4MCH, as discussed below. The increase in the prevalence of LARC was observed in both treatment and comparator counties but the increase was significantly greater among ICO4MCH counties in our second model, which excluded the county with hypothesized decreased implementation success of the EBS.

It is unclear why we observed a decrease in PTB only among non-Hispanic White women. It is possible that uptake of LARC differed by race-ethnicity. Unfortunately, program-level data and the secondary family planning utilization data were not disaggregated by race-ethnicity. We were therefore unable to determine if program reach or contraceptive method selection differed by race/ethnicity or any other demographic characteristics. In the future, program-level data will be collected in a way that allows for data to be disaggregated by race-ethnicity and age to help determine if the receipt of the LARC intervention may vary by demographic characteristics.

Trends in LARC utilization nationwide indicate that LARC receipt may differ by race-ethnicity of the woman seeking contraception, with Black and Hispanic mothers possibly more likely to select a LARC contraceptive method (45,59,60). Kavanaugh and Jerman (45) reported the prevalence of LARC usage by race/ethnicity for women 15-44 in 2014 as 13% among Non-Hispanic White women, 15% among Non-Hispanic Black women, 14% among women of multiple of other race, and 18% among Hispanic White women. Another study on postpartum LARC insertion in North Carolina by Goulding, et al. (59) observed increased odds of postpartum LARC insertion among Hispanic White women and Non-Hispanic Black women when compared to Non-Hispanic White women. It is unknown if Black and Hispanic women who received family planning services at a LHD with ICO4MCH funding were already more likely to have a LARC (and therefore not receive one as a result of the program). However, it is possible that an initial lower prevalence of LARC among White women could in part explain why we only observed a reduction in PTB among this population.

Despite possible increased selection of LARC contraceptive methods among Black and Hispanic women, the coercive history of contraception and sterilization practices in the U.S. cannot be overlooked when discussing the potential differential impact of this EBS and on the utilization of LARC methods by Women of Color. A qualitative research study of 50 women by Higgins, Kramer, & Ryder (61) found that Women of Color were more likely than Non-Hispanic White women to expect providers to recommend LARC and were also more likely to perceive the recommendation as motivated by their race or income. Future data collection for the ICO4MCH program should seek to collect patient-level perceptions of the LARC intervention and patient-level satisfaction with their contraceptive method of choice. The collection of this information would help program staff disentangle the complex factors that may be driving the observed differences in PTB.

Another possible explanation for these findings could be that the mechanisms driving PTB differed by race-ethnicity of the mother. It is possible that the nearly two-fold increased likelihood of preterm birth among Non-Hispanic Black women is driven by a mechanism not targeted through increased access to LARC and other family planning services. We hypothesized that the intervention would impact PTB through the reduction of unintended pregnancy and through increased birth spacing. It is possible that the selection of this EBS to reduce PTB may not have targeted the more systemic/structural mechanisms (i.e. Racism) that drive the disparities seen in PTB for Non-Hispanic Black and Hispanic women. Finally, the theory of racism as a fundamental cause of health inequities may in part explain why ICO4MCH only contributed to reductions in preterm birth among Non-Hispanic White women (62). Phelan and Link (62) explain that health promotion interventions tend to first impact those with more privilege and more access to resources because they are the first to use the information to advantage their own health. It is possible continued implementation of this EBS would lead to improved outcomes for all women if implemented for a longer period of time. Future interventions to reduce adverse birth outcomes should consider a specific focus on equity in birth outcomes as opposed to birth outcomes in general.

We expected ICO4MCH would have a similar impact on both PTB and LBW as we hypothesized a similar mechanism of action between the intervention and both birth outcomes (i.e. an increase access to contraception including LARC would lead to increased birth interval and reduced unintended pregnancy). Similarly, PTB is one of the leading causes of LBW, so we hypothesized the two outcomes would respond similarly to the EBS. In contrast, we only observed an impact on PTB. Our evaluation is not the first to find a significant impact of a LARC intervention for PTB but not for LBW. An evaluation of the Colorado Initiative, which sought to increase family planning services and LARC utilization for birthing people in Colorado through funding at the clinic level, also found a significant reduction in PTB but not LBW trends following implementation of the program (26). Evaluation of the Colorado Family Planning Initiative also documented a significant inverse relationship between higher county-level proportion of LARC utilization and county-level PTB but not LBW (26). Therefore, it is possible that interventions seeking to increase access to LARC may more effectively impact drivers of PTB and not LBW. However, future research is needed to disentangle mechanisms that impact the relationship between LARC utilization and adverse birth outcomes.

It is unclear why we observed an increase in LARC utilization from 2017-2019 among only 4 of 5 treatment groups. The one treatment county excluded in model 2 of the LARC utilization analysis was the only group among both treatment and comparator groups in which we observed a decline in LARC utilization among female-identifying clients between 2017-2019 (n=23). From 2013-2017, trends in LARC utilization in this treatment county were similar to trends in other treatment and control groups (i.e. a steadily increase over time from 2013-2017). The general increase in prevalence of LARC as a contraceptive method observed among the entire sample has also been documented in several other nationwide studies (43–45). The observed decrease in LARC utilization for this one county began in 2017.

Discussions with stakeholders revealed that these trends could be a result of several county-specific events. This treatment county experienced three hurricanes throughout the treatment period, one of which had a devastating impact on the LHD and surrounding area and occurred at the beginning of the intervention period. The hurricanes caused significant damages and clinic closures in the LHD. Stakeholders also revealed that the county had high turnover among their LARC providers and that there were times throughout the treatment period in which there was not a provider available to perform LARC insertion.

This treatment county is also demographically different than most other counties included in the analysis of LARC utilization and we were unable to control for potential confounders in the LARC models. This county is rural with over 40% of the population identifying as American Indian or Indigenous. Studies that determine prevalence of contraceptive use by race-ethnicity often group American Indian women as “other or more than one race”, so it is unclear whether LARC utilization is less common among this population (44,45). An analysis of reproductive health among American Indian women using the 2002 National Survey of Family Growth found that about 61% of urban American Indian women ages 15-24 did not use any form of contraception (63).

However, these data were from 2002 and included only American Indian women who resided in an urban area. Because the population of this one county is rural and because LARC utilization has increased nationwide substantially since 2002, these findings may not be representative of contraceptive practices among American Indian women in this county. Future studies on reproductive life planning practices and contraceptive methods of choice among rural American Indian women are needed to make better inferences about why we may have seen a decline in LARC utilization in this county despite having the LARC intervention.

Finally, this grantee consisted of one rural county. Therefore, any problems with data quality could have been more impactful than data quality issues in a more densely populated county or among a collaborative with multiple counties. This sparsely populated rural county could have also been impacted by saturation such that the number of women who wanted a LARC within this county who attend the LHD received it and therefore the trends in women using LARC was impacted.

Limitations

There were several limitations to this evaluation. First, only 1.5 years of birth certificate data was available post intervention period (June 1, 2017) at the time of this analysis whereas change in the long-term goals were expected about 3-5 years following intervention. We plan to examine whether our findings hold once 2019 data become available. As mentioned above, program-level data were not available disaggregated by race and ethnicity, and therefore we were not able to discern whether utilization of family planning services varied by the race or ethnicity of the women. We were unable to comprehensively account for siblings in the birth outcomes models. When possible, siblings were matched to each other via a fuzzy merge approach, using maternal date of birth, maternal location of birth (state and country), maternal race/ethnicity, parity, and child's month and year of birth. There were likely cases where sibling pairs were counted as individual observations, for example when more than one mother and child pairs had similar characteristics.

In the LARC utilization models, we were unable to adjust for any cofounders. The data source for contraceptive data also changed in 2017, which was the start of the intervention period. We were cautioned that data for 2017 may be of poor quality as the LHDs were preparing for the new data system. Finally, data reported for years 2013 and 2014 had high incidence of female clients with "unknown" contraceptive methods. Therefore, data from years 2013, 2014 and 2017 should be interpreted with caution.

This evaluation provides support that the ICO4MCH LARC EBS contributed to a reduction in PTB among treatment counties. However, another limitation to this evaluation is that, while birth outcomes models controlled for various confounding variables and other funded programs, grantees implement three EBSs as part of the ICO4MCH program. As a result, it is hard to discern which EBS resulted in change seen in preterm births in treatment counties as funding for and implementation of the EBSs all began June 1, 2016.

Four of five of the grantees also implemented another EBS aimed at smoking cessation that could have impacted PTB in treatment counties. Smoking is another risk factor for PTB and LBW, irrespective of other risk factors (20). Smoking has been shown to cause fetal growth restriction and placental complications (20) In a recent study of 1,390,742 births, smoking explained nearly 33% of the variation in preterm birth among extremely, very, and moderately preterm infants (22). Two of the five grantees implemented the Tobacco Cessation and Prevention aimed at decreasing primary, secondary and tertiary tobacco exposure. As part of the intervention, LHDs increased access to direct clinical support around tobacco use, screening and counselling using the 5As (Ask, Advice, Assess, Assist, Arrange) and Certified Tobacco Treatment Specialists (CTTSs). Two of the five grantees implemented Clinical Efforts Against Secondhand Smoke Exposure (CEASE). This intervention is also a tobacco cessation program which provides cessation resources to parents during a child's health care visit. Both grantees implementing these interventions also worked to increase access to the QuitlineNC, a statewide free tobacco cessation program. Any of these smoking cessation programs may have impacted preterm birth. We adjusted for other Reproductive Life Planning and Infant Mortality Reduction funding across the state, but we were unable to control for tobacco prevention and control funding, programs and policy external to ICO4MCH which may have an impact on PTB and LBW that was not accounted for. However, our birth outcomes models did control by for individual level smoking status.

Implications

Despite evidence that LARC can reduce unintended pregnancy and increase birth spacing, there are few studies which evaluate increasing access to LARC as an intervention for preventing adverse birth outcomes, like PTB and LBW. This evaluation was structured as a quasi-experimental difference in difference time series analysis with two primary aims: 1) to determine if trends in birth outcomes, specifically preterm and low birth weight births, improved after implementation of ICO4MCH in ICO4MCH counties compared to other counties in NC and 2) to determine if LARC utilization increased after implementation of the ICO4MCH intervention in local health departments in ICO4MCH counties compared to LHDs in North Carolina.

To our knowledge, this is the second study to find that funding to increase access to LARC methods may be effective at decreasing PTB but not LBW (26). While the PTB model was statistically significant overall, stratified models revealed a more nuanced story. While the ICO4MCH LARC intervention did not specifically seek to reduce racial disparities in PTB and LBW, it is noteworthy and concerning that findings suggest PTB was reduced mostly among those with the lowest overall incidence of PTB. Future reproductive life planning and LARC interventions should seek to intentionally evaluate the effectiveness of these interventions on both PTB and LBW, and should also seek to set up interventions so that program-level data can be disaggregated by race and ethnicity to better understand program impact. Future RLP/LARC interventions should also consider monitoring program uptake and/or conducting process evaluations to see who is benefitting from RLP/LARC programs prior to conducting evaluations on program impact. Future RLP/LARC programs should also seek to capture patient voice and satisfaction with the clinical encounter to ensure equal access and equity in outcomes. Finally, this evaluation lends support to LARC interventions as an effective strategy to reduce PTB.

Table 2. Characteristics of women (n=481,969) in 69 North Carolina Counties who Gave Birth Between January 1, 2013 and December 31, 2018

	All 69 counties N=481,969		Comparator Counties N=300,619		ICO4MCH Counties N=181,350		P-value (X^2)
	N	(%)	N	(%)	N	(%)	<.001
PTB (<37 weeks)							
No	442,715	91.90	276,427	91.99	166,288	91.73	
Yes	39,044	8.10	24,055	8.01	14,989	8.27	
Missing	210		137		73		
LBW (<2500 grams)							
No	447,630	92.90	279,873	93.10	167,757	92.50	<.001
Yes	34,251	7.10	20,697	6.90	13,554	7.50	
Missing	88		49		39		
Maternal Age							<.001
Under 20 years	29,734	6.17	19,074	6.34	10,660	5.88	
20-24 years	109,838	22.79	71,037	23.63	38,801	21.40	
25-29 years	139,464	28.94	87,846	29.22	51,618	28.46	
30-34 years	128,362	26.63	77,864	25.90	50,498	27.85	
35-39 years	61,435	12.75	36,895	12.27	24,540	13.53	
40 or more years	13,129	2.72	7,899	2.63	5,230	2.88	
Missing	7		4		3		
Maternal Smoking Status							<.001
Non-smoker	422,581	87.70	259,249	86.25	163,332	90.09	
Stopped Before Pregnancy	17,553	3.64	11,478	3.82	6,075	3.35	
Stopped After Pregnancy	10,163	2.11	6,864	2.28	3,299	1.82	
Continued Smoking	31,575	6.55	22,978	7.64	8,597	4.74	
Missing	97		50		47		
Maternal Education Level							<.001
Less than High School	69,628	14.49	41,343	13.79	28,285	15.63	
High School Grad or GED	106,474	22.15	69,575	23.21	36,899	20.40	
Some College	148,807	30.96	96,527	32.20	52,280	28.90	
Bachelor's Degree or More	155,756	32.40	92,301	30.79	63,455	35.07	
Missing	1,304		873		431		
Maternal Medicaid Status							<.001
No	226,989	47.10	137,370	45.70	89,619	49.40	
Yes	254,980	52.90	163,249	54.30	91,731	50.60	
Maternal Race/ Ethnicity							<.001
Non-Hispanic White	256,342	53.23	180,822	60.20	75,520	41.69	
Non-Hispanic Black or African American	108,675	22.57	58,405	19.44	50,270	27.75	
Non-Hispanic American Indian or Alaskan Native	7,102	1.47	1,716	0.57	5,386	2.97	
Non-Hispanic Asian or Pacific Islander	20,811	4.32	10,704	3.56	10,107	5.58	
Multiracial or Other	15,732	3.27	8,934	2.97	6,798	3.75	

Hispanic	72,892	15.14	39,809	13.25	33,083	18.26	
Missing	415		229		186		
Maternal Pre-pregnancy BMI							<.001
Underweight	17,772	3.77	11,334	3.85	6,438	3.62	
Normal	212,025	44.94	130,221	44.28	81,804	46.02	
Overweight	118,310	25.08	72,997	24.82	45,313	25.49	
Obese	123,710	26.22	79,509	27.04	44,201	24.87	
Missing	10,152		6,558		3,594		
Child's Sex							0.44
Male	246,307	51.10	153,500	51.10	92,807	51.20	
Female	235,658	48.90	147,116	48.90	88,542	48.80	
Missing	4		3		1		
Previous PTB							<.001
No	465,855	96.66	291,298	96.91	174,557	96.26	
Yes	16,077	3.34	9,295	3.09	6,782	3.74	
Missing	37		26		11		
Parity							<.001
Nulliparous	198,385	41.17	122,466	40.74	75,919	41.87	
1 prior birth	154,114	31.98	97,766	32.52	56,348	31.08	
2-3 prior births	108,725	22.56	67,894	22.59	40,831	22.52	
4 or more prior births	20,687	4.29	12,463	4.15	8,224	4.54	
Missing	58		30		28		
Pregnancy Weight Gain							<.001
Less than adequate	98,534	21.12	60,716	20.86	37,818	21.55	
Adequate	139,665	29.93	86,621	29.76	53,044	30.23	
Excessive	228,373	48.95	143,771	49.39	84,602	48.22	
Missing	15,397		9,511		5,886		
Rural-Urban Continuum						0.00	<.001
Urban	402,865	83.59	244,978	81.50	157,887	87.10	
Non-Metro, Urban	71,872	14.91	49,676	16.50	22,196	12.20	
Rural	7,232	1.50	5,965	2.00	1,267	0.70	
Concurrent RLP or IMR Funding							<.001
No	408,937	84.85	246,477	81.99	162,460	89.60	
Yes	73,032	15.15	54,142	18.00	18,890	10.40	
Diabetes (prior to or during pregnancy)							0.38
No	448,947	93.16	280,093	93.18	168,854	93.12	
Yes	32,973	6.84	20,491	6.82	12,482	6.88	
Missing	49		35		14		
Hypertension (prior to or during pregnancy)							0.40
No	440,875	91.48	274,904	91.46	165,971	91.50	
Yes	41,045	8.52	25,680	8.54	15,365	8.50	
Missing	49		35		14		
Enrolled in WIC							<.001
No	277,171	57.51	166,280	55.30	110,891	61.10	
Yes	204,798	42.49	134,339	44.70	70,459	38.90	

RLP: Reproductive Life Planning; IMP: Infant Mortality Reduction Funding; Women, Infant and Children (WIC)

Table 3. Adjusted Difference in Difference Models for Preterm Birth (n=464,983) and Low Birth Weight (465,057)

Model	**PTB Model**	**LBW Model**
	Beta (95% CI)	Beta (95% CI)
Treatment County	0.33 (0.21 - 0.45)	0.33 (0.20 - 0.45)
Birth after May 31, 2017	-0.07 (-0.13 - -0.01)	-0.04 (-0.11 - 0.02)
Interaction between Treatment County and birth after May 31st, 2017	0.09 (-0.01 - 0.19)	0.00 (-0.11 -0.11)
Time in years (Centered at June 1, 2017)	0.00 (-0.01 - -0.1)	0.02 (0.01 - 0.03)
Interaction between Treatment County and time in years	0.00 (-0.02 - 0.02)	-0.01 (-0.03 - 0.01)
Birth after May 31st, 2017 and time in years	0.02 (-0.03 - 0.08)	-0.01 (-0.08- 0.05)
Interaction between Treatment County, a birth after May 31st, 2017, time in years	-0.12 (-0.22 - -0.03)	-0.02 (0.12 - 0.08)

Note: Confounders included in models are: Maternal age (Categories: Under 20 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, 40 years); Maternal smoking status (Categories: Non-smoker, Stopped before pregnancy, Stopped after pregnancy, Continued smoking); Maternal Education (Categories: Less than high school, High School or GED, Some college, Bachelor's degree or more); Maternal Medicaid Status (Categories: Enrolled in Medicaid, not enrolled in Medicaid); Maternal race/ethnicity (Categories: Non-Hispanic White, Non-Hispanic Black or African American, Non-Hispanic American Indian or Alaskan Native, Non-Hispanic Asian or Pacific Islander, Multiracial or Other, Hispanic); Maternal Pre-Pregnancy BMI (Categories: Underweight, Normal, Overweight, Obese); Child's Sex (Categories: Male, Female); Previous PTB (Categories: Previous preterm birth, No prior preterm birth); Parity (Categories: Nulliparous, 1 prior birth, 2-3 prior years, 4 or more prior births); Pregnancy weight gain (Categories: Adequate, Excessive, Less than Adequate); Diabetes (Categories: No diabetes, Pre-pregnancy or gestational diabetes); Hypertension (Categories: No hypertension, Pre-pregnancy or gestational hypertension); WIC Enrollment (Categories: Enrolled in WIC, Not enrolled in WIC); Rural-Urban Continuum (Categories: Urban, Non-metro urban, Rural); Concurrent reproductive life planning or infant mortality reduction funding (Categories: Concurrent funding, No concurrent funding); County Aggregate (Categories: Outlined in the Selection of Treatment and Comparator Groups section of the methods).

Table 4. Trends in Percentage of LARC Utilization by Year Between 2013-2019

All Counties (N = 400,475)							
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Number of women who received IUD	5491	4376	4020	4284	4454	4117	4497
Number of women who received Implant	3078	2934	3577	4110	4352	4663	5522
Number of women who received LARC	8569	7310	7597	8394	8806	8780	10019
Total Female Clients	76012	61472	56054	54365	52863	49676	50033
Percent Methods that were LARC	11.27%	11.89%	13.55%	15.44%	16.66%	17.68%	20.03%
Treatment Counties and Collaboratives (N = 113,906)							
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Number of women who received IUD	1070	721	924	1105	995	1285	1139
Number of women who received Implant	691	623	832	1178	1124	1440	1472
Number of women who received LARC	1761	1344	1756	2283	2119	2725	2611
Total Female Clients	23079	16699	18221	15833	13796	13722	12556
Percent Methods that were LARC	7.63	8.05	9.64	14.42	15.36	19.86	20.8

Control Counties and Collaboratives (N = 286,569)							
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Number of women who received IUD	4421	3655	3096	3179	3459	2832	3358
Number of women who received Implant	2387	2311	2745	2932	3228	3223	4050
Number of women who received LARC	6808	5966	5841	6111	6687	6055	7408
Total Female Clients	52933	44773	37833	38532	39067	35954	37477
Percent Methods that were LARC	12.86	13.32	15.44	15.86	17.12	16.84	19.77

Table 5. Multilevel Regression Models for Percentage of LARC utilization in treatment county and intervention period (N = 400,475)

	Model 1A:	Model 1B:	Model 2A:	Model 2B:
	All Treatment Counties		4 of 5 Treatment Counties	
	Beta (95% CI)	Beta (95% CI)	Beta (95% CI)	Beta (95% CI)
Treatment county	-1.08 (-6.21 – 4.05)	-2.34 (-7.68 - 2.10)	-0.18 (-5.83 – 5.48)	-2.9 (-8.76 - 2.96)
Intervention Period (2017-2019)	4.92 (3.47 – 6.37)	4.27 (2.64 - 5.90)	5.44 (3.99 – 6.89)	4.27 (2.73-5.81)
Interaction between intervention period and treatment county	-	2.94 (-.53 - 6.41)	-	6.35 (2.77 - 9.94)
Intercept	11.96 (9.49 – 14.43)	12.24 (9.75 - 14.73)	11.74 (9.25-14.23)	12.24 (9.74 - 14.74)

Table 6. Predicted Percent LARC Utilization for Model 2

	Intervention period (2017-2019)	Not intervention period (2013-2016)	Difference
Treatment county	19.96	9.34	10.62*
Control county	16.51	12.24	4.27*
Difference	-	-	6.35*
Note: * p<.05			

Figure 3. Preterm Birth Model

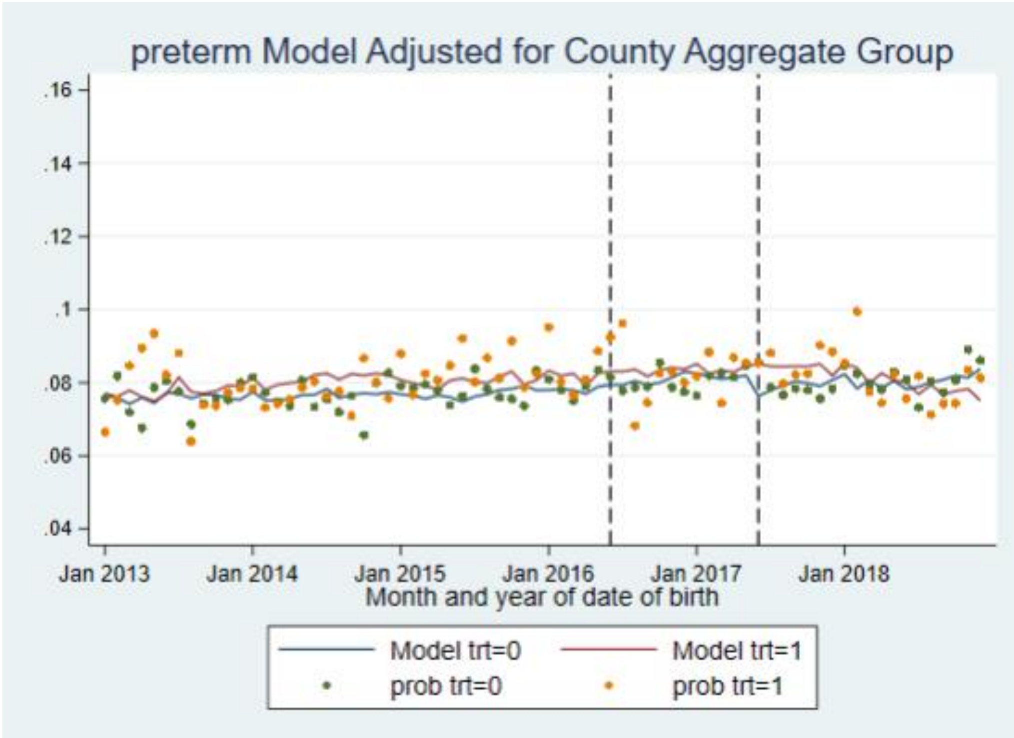


Figure 4. Preterm Birth Model – Only Non-Hispanic Black/African American Mothers

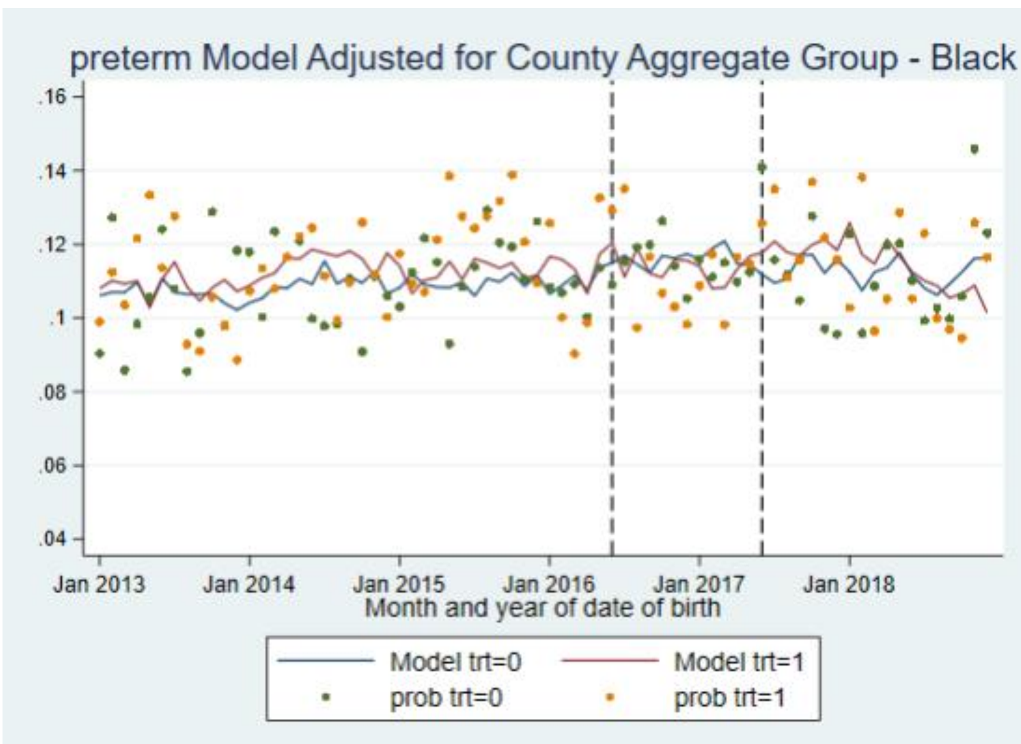


Figure 5. Preterm Birth Model – Only Non-Hispanic White Mothers

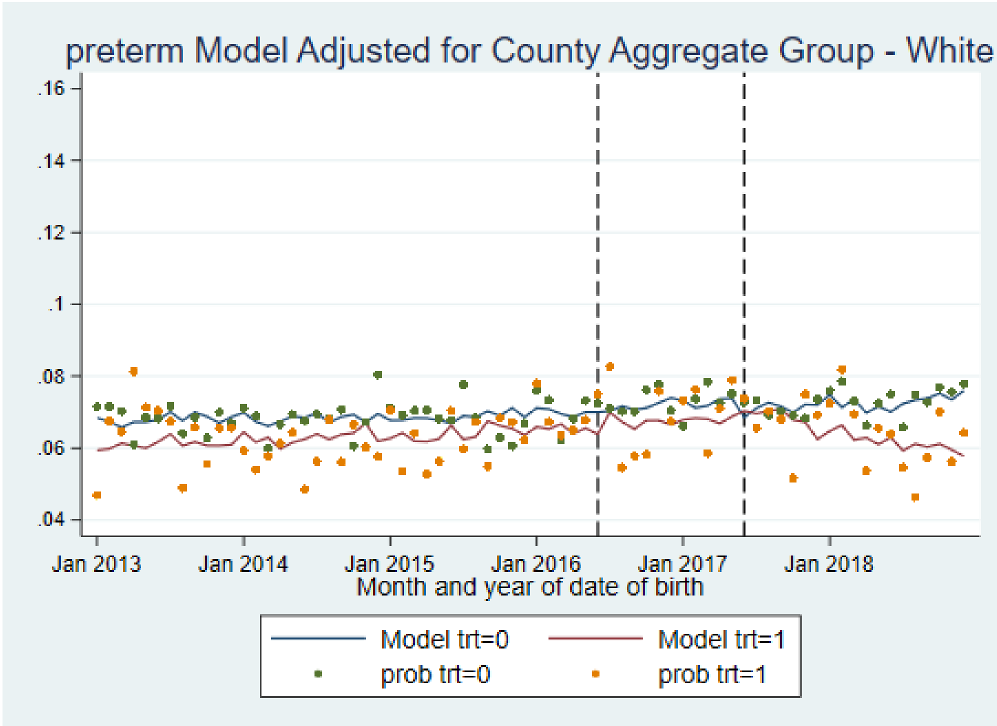


Figure 6. Preterm Birth Model – Only Hispanic Mothers

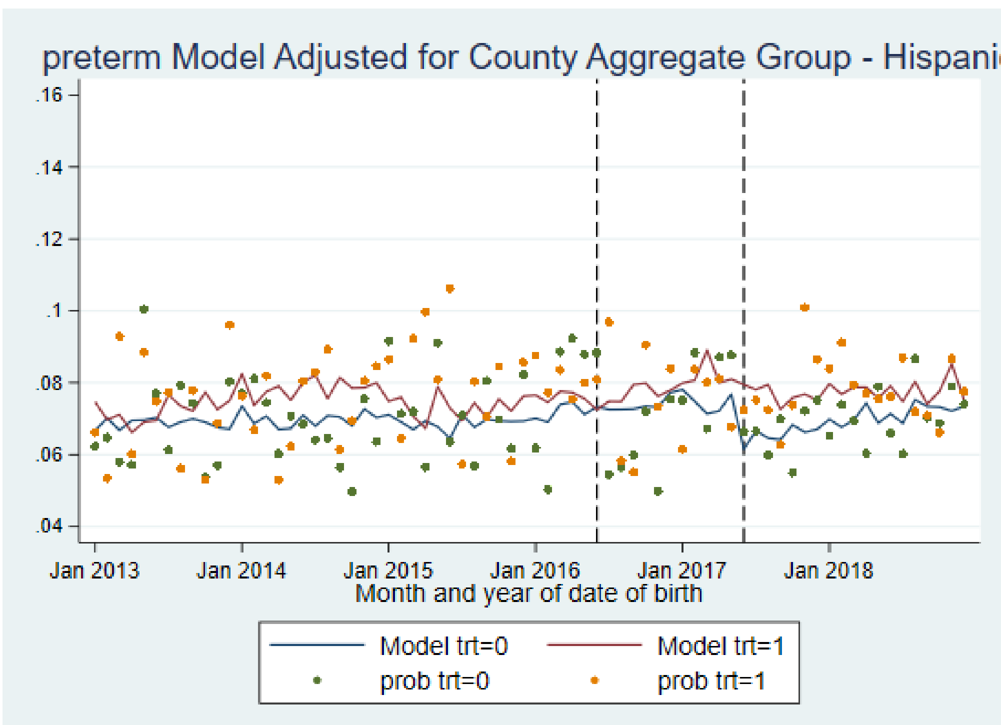
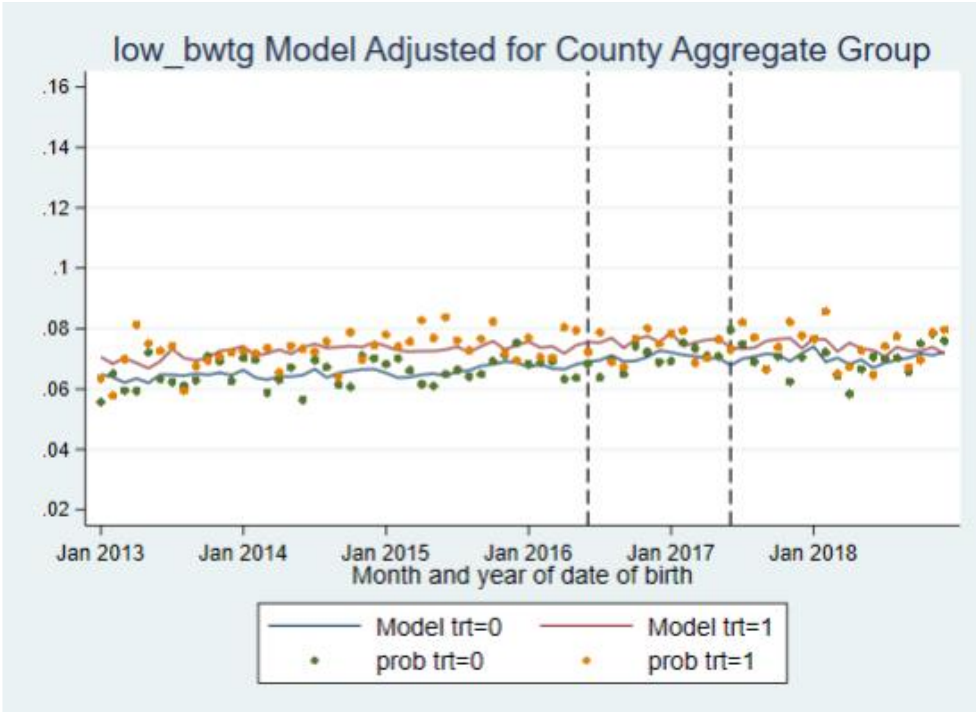


Figure 7. Low Birth Weight Model



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Appendix

Table 7. Table of Measures

Measure	**Source**	**Coding**
Exposure		
ICO4MCH funding	ICO4MCH funding was determined using the county of residence of the mother on the child’s birth certificate.	ICO4MCH funding was dichotomized into treatment (1) or comparator county (0) of residence
Outcomes		
PTB	The preterm birth variable was determined using the obstetric estimate of gestation (in completed weeks gestation)	PTB was dichotomized into preterm birth (<37 weeks completed gestation) (1) or not a preterm birth (≥37 weeks completed gestation) (0)
LBW	The low birth weight outcome was determined using the birth weight question on the childbirth certificate.	The continuous birthweight variable was dichotomized into: 1=low birth weight birth (<2500 grams) 0=not a low birth weight birth (≥2500 grams)
Covariates		
Maternal Age	The age of the mother was determined using the mother’s year, month, and day of birth on the child’s birth certificate. Maternal age at the time of birth was calculated. In the analysis, the maternal age variable was restricted to women between 10 and 55 based on advice from NC DPH.	Maternal age was grouped into the following categories: 1=Under 20 years 2=20-24 years 3=25-29 years 4=30-34 years 5=35-39 years 6=40 plus years
Maternal Smoking Status	The smoking status of the mother was determined using the “cigarette smoking before and during pregnancy questions” on the child’s birth certificate. This variable includes the daily averages (# of cigarettes or packs smoked) for the 3 months before pregnancy and each trimester. Women with missing smoking data from any period were coded as missing.	Non-smokers (0) were coded as women who reported 0 cigarettes smoked throughout the 3 months before and every trimester during pregnancy. Women who reported smoking the three months prior to pregnancy but not any period during pregnancy were coded as having stopped smoking prior to pregnancy (1). Women who smoked pre-pregnancy and smoked during the first two trimesters but not the third trimester were coded as having stopped smoking during

		pregnancy (2). Women were coded as having continued smoking (3) if they smoked the third trimester, even if smoking was reduced or smoking was not reported in the previous two trimesters. The resulting groups were: 0=Non-smoker 1=Stopped before pregnancy 2=Stopped after pregnancy 3=Continued smoking
Maternal Education	Maternal education was determined using the mother's education question on the child's birth certificate.	While the birth certificate includes 8 categories of education, we collapsed these categories into 4: 1=Less than high school 2=High School or GED 3=Some college 4=Bachelor's degree or more
Maternal Medicaid Status	The Medicaid status of the mother was determined from the linked Medicaid claims data available in the "Babylove" dataset.	Medicaid status was dichotomized into enrolled in Medicaid (1) and not enrolled in Medicaid (0). (Women who had filed a Medicaid claim and were approved were coded as enrolled in Medicaid)
Maternal Race/ethnicity	The maternal race/ethnicity variable was determined using the mother's race variable on the child's birth certificate. A non-bridged approach used to further categorize variables based on advice from NCHS due to concerns with the methodology of the bridged race/ethnicity categories.	Maternal Race was grouped into the following categories: 1=Non-Hispanic White 2=Non-Hispanic Black or African American 3=Non-Hispanic American Indian or Alaskan Native 4= Non-Hispanic Asian or Pacific Islander 5= Multiracial or Other 6= Hispanic
Prepregnancy BMI	The mother's pre-pregnancy BMI was determined using the mother's reported pre-pregnancy weight and the mother's reported height on the child's birth certificate.	The mother's BMI was categorized into standard BMI categories based on height and weight: 1=Underweight 2=Normal 3=Overweight 4=Obese

Child's Sex	The child's sex was determined using the sex of the child listed on the child's birth certificate.	Child sex was dichotomized into Male (1) and female (2)
Previous PTB	The previous preterm birth variable was developed using "risk factors in this pregnancy" section on the child's birth certificate. If the question "previous preterm birth" was endorsed, a woman was coded as having a previous preterm birth (1).	Previous preterm birth was dichotomized into No previous preterm birth (0) and preterm birth (1)
Parity	Parity was determined based on the "number of previous live births" question on the child's birth certificate.	Reported number of previous children were categorized into the following groups: 0=Nulliparous 1=1 prior birth 2=2-3 prior years 3=4 prior births
Pregnancy weight gain	Pre-pregnancy weight gain was developed using the mother's reported weight preg-pregnancy and at delivery as well as her height (to determine BMI). Categories were defined as less than adequate, adequate, or excessive based on ACOG recommendations for pregnancy weight gain based on BMI group. Pre-pregnancy BMI under 18.5: 28–40 pounds Pre-pregnancy BMI 18.5–24.9: 25–35 pounds Pre-pregnancy BMI 25–29.9: 15–25 pounds Pre-pregnancy BMI 30 or more: 11–20	If a woman fell below the recommended pregnancy weight gain, she was coded as less than adequate weight gain (0). If a woman gained over the recommended weight, she was coded as excessive weight gain (2). If a women's weight gain fell within the recommended values, she was coded as adequate weight gain (1).
Diabetes	The pre-pregnancy or gestational diabetes variable was developed using "risk factors in this pregnancy" section on the child's birth certificate. The maternal diabetes questions separate pre-pregnancy and gestational diabetes. For our analysis, women were coded as 1 if they experienced diabetes either before or during pregnancy.	The diabetes variable was dichotomized into no diabetes (0) and pre-pregnancy or gestational diabetes (1)
Hypertension	The pre-pregnancy or gestational hypertension variable was developed using "risk factors in this pregnancy" section on the child's birth certificate. The maternal	The hypertension variable was dichotomized into no hypertension (0) and pre-pregnancy or gestational hypertension (1

	hypertension questions separate pre-pregnancy and gestational hypertension. For our analysis, a woman was coded as 1 if they experienced hypertension either before or during pregnancy.	
Enrolled in WIC	Whether a mother was enrolled in WIC was determined from the child's birth certificate based on the question "Did mother get WIC food for herself during this pregnancy?"	0=Not enrolled in WIC, 1=enrolled in WIC
Rural-Urban Continuum	The rural-urban variable was defined based on the USDA's UCC 2013 criteria. This dataset includes classification for all counties in every state. The mean of all counties in a collaborative was used to categorize the county-aggregate level.	While this dataset includes detailed coding for nine different types living areas on the rural-urban continuum, we collapsed the coding into the following three smaller groups: 1=urban 2=non-metro urban 3=rural
Concurrent RLP or IMR Programming	The indicator variable for additional RLP/IMR funding was developed based on information shared by the Division of Public Health Women's Health Branch using an external dataset that contained various funding in North Carolina between 2016-2018.	Any county included in this analysis (n=69) who received either additional funding for reproductive life planning or infant mortality reduction (between 2016-2018) were coded as a 1. Counties without these programs were coded as 0.
County Aggregate	The county aggregate adjustment variable includes the groups outlined in the treatment and control county section. In total, there were five treatment groups and 18 control groups	A detailed description of county aggregates are outlined in the "Selection of Treatment and Comparator Groups" section