The Effect of Hospital Closures on Maternal and Infant Health*

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Abstract

This paper studies the impact of hospital maternity ward closures on birth outcomes in the United States. On the one hand, closures can affect health outcomes through an increase in travel distance, resulting in a decreased utilization of prenatal care and an increase in out-of-hospital birth. On the other hand, women may be exposed to a new set of providers with potentially better resources and different delivery practices, which could be beneficial if the new providers are of higher quality. Using national Vital Statistics data, I estimate the impacts of closures using a matched difference-in-differences design. Rural closures appear to create net benefits: I find a large decline in Cesarean births alongside precise null effects for infant and maternal outcomes. This effect is driven by low-risk women shifting to hospitals with more judicious Cesarean practices, suggesting closure hospitals were over-performing Cesareans. By contrast, urban closures have deleterious effects. Cesareans rise (with no improvement in maternal and infant outcomes) in the hospitals that absorb the closures.

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Since the early 2000s, hundreds of hospitals have closed or are at risk of closing. Moreover, when hospitals are financially strained, they may eliminate their least profitable services. Maternity care is often one of the first services to be eliminated due to high costs and low reimbursements. As a result, nine percent of counties lost maternity services between 2004 and 2014 (Hung et al. (2017)) and today almost half of counties have low or no access to maternity care (March of Dimes (2020)). The increase in maternity ward closures has raised concerns about access to care, increased travel distances, and growing health disparities.[1,2]

In this paper, I study the impacts of maternity ward closures on the health outcomes of women and infants. Depending on the context, maternity ward closures may have either positive or negative effects on maternal health. On the one hand, increased travel distances may generate adverse health consequences. Large increases in travel distance could increase out-of-hospital births and decrease utilization of prenatal care. To avoid the uncertainty of traveling the increased distance while in labor, women may prefer to schedule an induction. Although scheduled elective inductions allow hospitals and doctors to benefit from greater control over the flow of patients, they may set off a "cascade of interventions" whereby the birthing process may become increasingly medicalized and ultimately result in a Cesarean delivery (Lewis et al. (2019)). Any decline in maternity ward access is especially concerning in the U.S. context, given levels of infant and maternal mortality as well as Cesarean rates well in excess of levels in other rich countries (OECD (2019)).

On the other hand, the closure of maternity wards could improve health outcomes. When a maternity ward closes, women are shifted to other hospitals and exposed to the delivery practices and resources of that hospital. Delivery practices vary greatly between hospitals, with Cesarean delivery rates ranging from 19 percent to 48 percent across hospitals (Card

[1]Several bills aimed at increasing access to maternal healthcare have been presented to Congress. For a brief description of bills introduced in 2019 and 2020, see https://www.kff.org/womens-health-policy/fact-sheet/analysis-of-federal-bills-to-strengthen-maternal-health-care/

[2]Several recent articles have highlighted the concerns regarding maternity ward closures. For a few examples, see https://www.nytimes.com/2020/05/05/parenting/coronavirus-black-maternal-mortality.html, https://www.usnews.com/news/healthiest-communities/articles/2019-06-13/what-happens-when-rural-communities-lose-their-hospital-maternity-care, and https://www.npr.org/sections/health-shots/2016/02/24/467848568/more-rural-hospitals-are-closing-their-maternity-units.

et al. (2019)). If the closure hospital is of lower quality, the benefits of shifting to an alternative hospital may outweigh the costs of reduced access to local care.

Since maternal mortality is rare in rich countries, Cesareans can be used as a metric of how maternity ward closures impact maternal health. The American College of Obstetricians and Gynecologists (ACOG) highlights that the rapid increase in Cesarean births without a concurrent increase in maternal or fetal morbidities suggests that Cesarean births may be overutilized in the United States. ACOG provides guidelines for doctors to reduce primary Cesarean births, highlighting that for most pregnancies Cesarean delivery carries a greater risk of maternal morbidity and mortality than vaginal delivery (ACOG (2014)). Thus, if the Cesarean rate rises without an underlying justification (e.g., improvements in infant health or an increase in the Cesarean rate among high-risk women), this suggests more women are exposed to an increased risk of maternal morbidities without any clear benefits. Likewise, if the Cesarean rate falls without any subsequent harms (e.g., infant health is no worse off and high-risk mothers still receive Cesareans), this suggests that fewer women are unnecessarily exposed to a strong risk factor of maternal morbidities.

To study the relationship between maternity ward closures and birth outcomes, I use national birth certificate records from the National Center for Health Statistics (NCHS) from 1996 to 2018. These data provide the universe of births, with rich details on characteristics of the pregnancy, labor, and birth outcomes. The restricted-access files contain additional information on county of residence and county of birth, allowing me to precisely identify when a woman's residence county loses access to maternity care. Using this information, I identify counties that go from having a hospital with a maternity ward to having no hospitals with a maternity ward, an event that is mostly concentrated in rural areas.

To quantify how maternity ward closures affect women and infants, I adopt a matched difference-in-differences approach exploiting variation in the timing of closures, defined as the year when a county loses all maternity services. Using detailed demographic and economic characteristics at the county level, I construct a matching algorithm to find a set of counties that do not lose maternity services to form a control group. I then compare the evolution of health outcomes for women and infants in treated and comparison counties around the time of the maternity ward closure.

I do not find any evidence of adverse impacts on infant health outcomes. I can rule out relatively small deleterious effects on low birth weight, Apgar scores, and preterm birth, rejecting increases in low birth weight of more than 2.9 percent, increases in the share of births with an Apgar score below 7 of more than 11.4 percent, and increases in preterm birth of more than 1.5 percent.[3] While I cannot rule out small increases in infant mortality due to a small baseline mortality rate, the precisely estimated zero effects on other infant health outcomes provide reassuring evidence that maternity ward closures do not harm infants.

Likewise, I do not find evidence that maternity ward closures harm maternal health—if anything, birth outcomes appear to improve. I do not find evidence that maternity ward closures lead to an increase in inductions or generate a "cascade of interventions." Instead, I find that women residing in counties that experience a maternity ward closure have significant *reductions* in Cesarean births relative to the matched control counties. Further, I find support for the idea that local provider practice plays an important role in the health impact of maternity ward closures. The reduction in Cesarean births is concentrated among women who move to providers with a lower propensity to perform a Cesarean following closure.

The reduction in Cesarean deliveries is driven by women with low medical risk factors. Because Cesarean births are major abdominal surgeries and are associated with increased risk of maternal morbidity, they should be reserved for women who are unable to have a safe and healthy vaginal delivery. I show that maternity ward closures are associated with lower rates of Cesarean births for women predicted to be at low-risk for complications, calculated as a function of age and other medical attributes, and no changes in rates for high-risk women, suggesting that women benefit from the new providers.

In the last part of the paper, I investigate whether maternity ward closures differ across

[3]The Apgar score assesses a newborn's color, heart rate, reflexes, muscle tone, and respiration. Scored out of 10, a score of 7 or more is considered "reassuring," while scores below 7 are considered abnormal.

rural and urban areas. Closures of major urban maternity wards could have very different effects compared to the closure of a small rural maternity ward. In particular, urban maternity wards perform a large number of births, potentially resulting in overcrowding in the surrounding hospitals following its closure. Using hospital discharge data from Texas, I identify closures at the zip code level, allowing me to look at counties that have multiple maternity providers. I find that maternity ward closures in Texas resulted in increases in Cesarean births at the hospitals near the closure and the increase is driven by the largest closures. This suggests that the rural closures, with an average of around 120 births per year prior to closure, are able to be smoothly absorbed into the surrounding hospitals. On the other hand, with around 500 births per year prior to closure, urban closures are larger and may create more disruptions at the nearby maternity wards.

This paper contributes to the expansive literature studying maternal and infant health. Several papers study how policies and environments impact health outcomes (Aizer et al. (2007), Almond et al. (2011), Almond et al. (2012), Evans and Garthwaite (2014), Chen et al. (2016), and Kuziemko et al. (2018)). Others investigate the impact of access to hospitals and clinics on utilization of care (Currie and Reagan (2003) and Lu and Slusky (2016)). I complement this literature by documenting how access to hospital-based maternity services in a woman's local area impacts birth outcomes.

In addition, this paper is related to the literature on Cesarean birth. Currie and MacLeod (2017) find that improved decision making among providers could reduce Cesarean births for low-risk women. Other papers study the health impacts of Cesarean deliveries, often finding an association between Cesarean birth and respiratory issues (Costa-Ramón et al. (2018), Costa-Ramón et al. (2020), and Card et al. (2019)). In my paper, I document a strong reduction in Cesarean deliveries concentrated among low-risk women. I provide suggestive evidence that this reduction is a result of provider practices, suggesting the delivery patterns of the doctor at birth plays an important role in determining the mode of delivery following maternity ward closures in rural areas.

Several papers have studied the relationship between maternity ward closures and birth outcomes (Lorch et al. (2013), Avdic et al. (2018), Hung et al. (2018), Hussung (2018), and Kozhimannil et al. (2018)). The results in this literature are mixed, with some papers finding adverse effects while others find no effect or even positive effects. Much of the literature has focused on simple correlations or one geographic area. One paper, Avdic et al. (2018), studies maternity ward closures in Sweden using an experimental design and finds adverse effects on maternal health but improvements in fetal health. Relative to these papers, I focus on the entire United States using a matched difference-in-differences design to allow for estimation of causal effects. In addition, this paper draws comparisons between rural and urban closures, highlighting the differential impacts that may occur based on geographic location.

The rest of the paper is organized as follows. Section 1 describes the data sources I use, and Section 2 discusses how maternity ward closures could impact health outcomes in rural and urban areas. In Section 3 I discuss my research design and estimation strategy. Sections 4, 5, and 6 present results for rural closures using the national birth certificate data. Section 7 presents results for urban closures in Texas and Section 8 concludes.

1 Data

1.1 Birth Certificate Data

The main analysis in this paper utilizes the U.S. Cohort Linked Birth/Infant Death Data Files provided by the National Center for Health Statistics (NCHS) for the years 1996 through 2018 (National Center for Health Statistics (2018)).[4] The vital statistics data contain information on maternal and infant socio-demographic characteristics such as race, ethnicity, education, and age. The data also contain details of the pregnancy and birth, including prenatal care, health risk factors, complications, and method of delivery. Information on the

[4]Cohort-linked birth and death certificates were not created for 2003 and 2004. The data for 2003 and 2004 are from the U.S. Natality Detail Files (National Center for Health Statistics (2004)).

infant's health, such as gestational age, birth weight in grams, and mortality within one year of birth, are also available in the data. In addition, I have access to the restricted-access files, which contain relevant geographic information, including women's county of residence and county where the birth occurs.

In the NCHS data, I identify when a county experiences a "complete" loss of maternity services. I classify a county as having lost all maternity services if the county observes a drastic reduction in births. I count the total number of births occurring in a county in a given year and calculate 3-year averages. A county "loses services" in year n if the 3-year average in years $n-1$, $n-2$, and $n-3$ is more than 15 births while the 3-year average in years n, $n+1$, and $n+2$ is less than 5 births. Importantly, this method does not identify counties that have other providers of maternity care after a hospital closes its maternity ward. Since most urban counties have more than one hospital providing maternity care, this method mostly identifies rural counties. Figure 1 displays the number of counties offering maternity care through time. The number of counties losing services is fairly consistent across years, with around 16 closures each year.

Figure 2 plots the average number of births in a county around the year of closure. The average number of births leading up to a closure is around 120 births per year. There is a significant drop in the number of births in the year prior to closure due to closures occurring at various points in calendar time. Upon closure, births in treated counties drop to zero, confirming a large "first stage." Though births drop dramatically in treatment counties, a county that closes its maternity ward could still see a small number of births post-closure due to isolated events. In particular, a woman may show up to the emergency room to deliver in a hospital that does not typically provide maternity services or a woman may (intentionally or unintentionally) give birth out of a hospital within the county.

1.1.1 Characteristics of the National Sample

Table 1 reports summary statistics for various groups in the NCHS data. Column 1 presents summary statistics for counties that close their maternity ward at any point between 1996 and 2018 ($N = 391$), Column 2 presents summary statistics for counties without any maternity services from 1996 through 2018 ($N = 1,150$), and Column 3 presents summary statistics for counties providing maternity services continuously from 1996 to 2018 ($N = 1,591$). Counties that experience a closure have a smaller population than counties that provide maternity services continuously, but are larger than counties that never offered maternity services during the sample period. The closure counties are generally small and rural, with an average population of around 22,000. Relative to the counties that always had maternity services, counties that lose services or never had services have fewer women of childbearing age, a higher share Black, and a lower share of college completion. In addition, the unemployment rate is higher and the county has fewer establishments. In Appendix Table A1, I show the hospitals that close tend to be smaller, as measured by the number of births and the number of beds, as well as tend to provide less specialized birthing care, as measured by the presence of a neonatal intensive care unit (NICU).

1.2 Texas Inpatient Discharge Files

As a complement to the national birth certificate data, I utilize the Texas Inpatient Public Use Data Files (PUDF) provided by the Texas Health Care Information Collection (THCIC) from 2000 to 2014 (Texas Department of State Health Services (2021)). The PUDF contain clinical and demographic information for individuals discharged from state-licensed hospitals in Texas that are required to report data to THCIC. Certain rural, military, and veteran hospitals are exempt from reporting requirements.

The PUDF contain details on patient age, gender, zip code of residence, admissions source, and discharge status. In addition, the PUDF include diagnosis and procedure variables coded using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Following Kuklina et al. (2008), I identify inpatient records as births if they contain diagnosis and procedure codes that pertain to births. I also have the zip code of the hospital.

The Texas data have several advantages over the NCHS birth certificate data. First, I am able to look at closures within a county that still maintains other maternity wards, such as urban closures. This data source allows me to draw comparisons between urban and rural closures. In addition, I am able to more precisely identify which women are impacted by the closure since I observe their home zip code and the location of the nearest hospitals with a maternity ward. Counties can be large and a woman may be closer to a hospital outside of her county of residence, but I do not have access to geographic details finer than county in the national data. Finally, since the data are discharge records, diagnosis and procedure codes are available. This allows me to look at specific codes that indicate a severe maternal morbidity, which is not available in the birth certificate data.[5] The disadvantages of the Texas data are the non-universal coverage of records and the inability to incorporate closures from other states.

Identification of maternity ward closures in Texas combines information gathered from several sources. I utilize the American Hospital Association's Annual Survey to determine if a hospital is providing maternity services. Hospitals report if they provide maternity care, which I use to determine whether and when a hospital stops providing maternity care. Not all hospitals report to the AHA, so I augment this information with the PUDF data.[6] The majority of hospitals are present in both the AHA Annual Survey and the PUDF data. A small number of hospitals are only present in the PUDF data. In this case, I identify the hospital as ceasing to offer maternity services if it stops reporting births in the PUDF data.[7]

[5] I define "severe maternal morbidity" using the CDC definition and corresponding ICD-9 codes for diagnoses (e.g., eclampsia, acute myocardial infarction, acute renal failure) and procedures (e.g., blood transfusion and hysterectomy).

[6] In particular, a parent hospital may report data for its own physical hospital, but its subsidiary hospitals may not report their own information. When hospitals merge, they may then report only one data point in the AHA Annual Survey, even when two physical hospitals remain.

[7] If the AHA Annual Survey indicates a hospital no longer offers maternity care, but the PUDF data contain birth records for that hospital, I consider the PUDF data to be correct since the PUDF data are true

1.2.1 Characteristics of the Texas Sample

Table 2 reproduces summary statistics for Texas. While closures in the Texas data are defined at the zip code level, I aggregate up to the county level in order to draw comparisons to the national data in Table 1. The counties in Column 1 have at least one zip code experiencing a change in distance to the nearest hospital with a maternity ward between 2000 and 2014, while the counties in Column 2 do not have any zip codes experiencing a change in distance. The counties that experience a closure in the Texas data are more populous, both relative to the non-closure counties in Texas and the closure counties identified in the NCHS data. Thus, when looking at the impact of closures in Texas, I do not consider an analogous sample to the NCHS data. In the NCHS data, I focus on rural closures, while in the PUDF data I focus on urban closures. There could be different impacts of maternity ward closure in urban and rural areas, which I explore in Section 2.

1.3 Other Data

I utilize additional sources of data to augment my analysis. I make use of County Business Patterns to obtain the number of establishments in a county in 1995. In addition, I obtain county-level population, per capita income, and per capita transfers in 1995 from the BEA's Regional Economic Information System. I use the BLS's Local Area Unemployment Statistics to obtain the unemployment rate in 1995. Finally, I utilize Census data to obtain information on education levels and demographic characteristics.

hospital discharge files rather than a hospital administrator's self-reported information. In this case, I do not indicate the hospital as ceasing to offer maternity care until it also stops reporting births in the PUDF data. Note that the opposite is not true: if a hospital indicates that it offers maternity care in the AHA data, but I do not find birth records for that hospital in the PUDF data, I take the AHA data as correct since there are reporting restrictions that may cause the PUDF data to be censored. When possible, if there is a disagreement between the PUDF data and the AHA Annual Survey, I confirm closure of the maternity unit using Google searches, local newspaper articles, and/or searching through the hospital's list of services on its website using the Wayback Machine.

2 Background on Maternity Ward Closures

Providing labor and delivery services is expensive, requiring low patient-to-nurse ratios and access to surgical and monitoring equipment. In addition, reimbursements rates are often low since Medicaid covers a significant portion of births. The combination of high costs and low reimbursements has led some financially-strained hospitals to close their maternity wards. These closures can impact health outcomes through several channels, including changes in distance, changes in quality, and spillovers in surrounding areas. Figure 3 highlights the potential channels through which maternity ward closures can impact health outcomes.

Women whose local maternity ward closes ("closure women") will have a change in the travel distance to the nearest hospital with a maternity ward. The increase in travel distance could negatively impact health outcomes if the increase results in more out-of-hospital births. In the United States out-of-hospital birth is more dangerous and results in higher mortality compared to hospital birth (Grünebaum et al. (2020)). In addition, some women may experience reduced access to prenatal care in their county of residence if maternity ward closures lead to obstetricians leaving the area or if prenatal care was provided in the hospital. This could lead to longer travel distances for prenatal care, potentially decreasing women's utilization of prenatal care. Regular prenatal care can identify potential obstetric complications, and pregnancies with no or limited prenatal care are associated with increased morbidity and mortality (Moore et al. (1986), Twizer et al. (2001), and Vintzileos et al. (2002)). Increased travel distance could also impact the procedures performed during the birth. In particular, women and/or providers may schedule inductions in order to minimize uncertainty regarding traveling far distances while in labor. An increase in inductions could result in an increase in Cesareans via the "cascade of interventions," where more medical interventions are performed following an induction, ultimately resulting in a Cesarean.

The impact of travel distance is likely to be large for rural closures. The average travel distance to a maternity ward following closure for a woman in a rural area in my sample is more than 30 miles. A woman in an urban area in my sample, on the other hand, only has to travel around 7 miles following the closure of a maternity ward. If the potential mechanisms described above exist, they are likely to be stronger in rural areas due to the longer distances.

In addition to the change in travel distance, there may also be a change in the quality of the closest hospital. Women may be exposed to higher-quality hospitals and providers if the hospital that closes its maternity ward is of lower quality. For rural women, the potential quality improvements may be large, while the potential quality gains are less clear for urban women. The hospital data from the AHA Annual Survey, summarized in Table A1, suggests that rural hospitals are small and do not provide advanced neonatal care. In particular, no rural hospital that closed its maternity ward had a Neonatal ICU, while around 2% of the urban maternity ward closures in Texas did. In addition, the number of births in rural hospitals is relatively small, with only around 120 births per year prior to closure. Urban hospitals, on the other hand, had more than 500 births prior to closure. If there is "learning by doing" in maternity care, the doctors in rural areas will be behind those in urban areas.[8]

In addition to the closure women, there could potentially be spillover effects on the women at the hospitals where the closure women go ("receiving women"). If the closure women create a strain on the surrounding hospitals, there could be decreases in the quality of care for receiving women. The impact of spillovers is likely small for rural closure. With only 120 births per year prior to closure, these women may easily find beds in surrounding areas without much impact. The urban closures have more potential to create negative spillovers, with more than 500 births prior to closure. This section highlights that, for rural closures, most impacts are likely to be concentrated among the closure women, with competing positive and negative forces, while receiving women are unlikely to be impacted. Urban closures, on the other hand, may have small impacts on the closure women but have the potential to affect the receiving women.

[8]Several papers have studied "learning by doing" in medical care, though none have focused on maternity care. See Bridgewater et al. (2004), Contreras et al. (2011), Halm et al. (2002), and Vickers et al. (2007) for examples.

3 Empirical Strategy

The goal of this study is to estimate the reduced-form impact of losing access to hospital-based maternity services on health outcomes of women and their newborns. To assess the impact of losing hospital-based maternity services, I employ a matched difference-in-differences design. In the first part of the paper focusing on rural closures, counties that offer hospital-based maternity services in 1996 and lose those services between 2002 and 2012 (and do not re-gain those services) serve as the treated counties in the analysis. Counties that continually provide maternity services from 1996 to 2018 serve as the potential control group.

3.1 Matching Procedure

I implement a matching procedure to generate balance along observable characteristics between treatment and control areas. To be eligible for inclusion in the matching procedure, treatment counties must experience a closure of hospital-based maternity services between 2002 and 2012. Potential control counties must have continual services from 1996 to 2018. I exclude counties that lose services outside of the 2002 to 2012 range and counties that never provide maternity services from 1996 to 2018 from the matching procedure.

I use a parsimonious set of characteristics to match each treated county to a counterfactual control county. Treated counties are matched to non-adjacent counties within the same state. It is important to match within the same state as many health policy decisions (e.g. Medicaid/Medicare policies and medical malpractice laws) occur at the state level and these policies can impact pregnancy and birth outcomes (Aizer et al. (2007), Currie and MacLeod (2008), and Kuziemko et al. (2018)). Within state matching ensures treatment and control counties are similar along observable characteristics and experience the same broader health policy environment. However, allowing for unrestricted matching within the state would be problematic as it could create a treatment-control pair that are geographic neighbors. The control could then be impacted by the closure through potential spillover effects. Matches are restricted to be nonadjacent counties to avoid control county contamination.

I use propensity score matching and match based on population, number of establishments, unemployment rate, median household income and transfers, percent Black, percent female aged 18 to 44, and percent with a bachelor's degree or higher. Each county that experiences a maternity ward closure is matched to the county with continuous maternity services with the closest propensity score.[9] Control counties are then assigned the same "closure" date as their corresponding matched treatment county. I can then use the observably similar control county to estimate the counterfactual outcome paths for the treated county had the closure not occurred.

3.2 Baseline Specification

To estimate the impact of closure on birth outcomes, I compare changes in the outcomes of interest for treated and control counties around the time of a treated county's closure. I estimate a fully dynamic matched difference-in-differences regression of the form:

$$Y_{ct} = \sum_{\tau \neq -1} \left[\theta_\tau \alpha_\tau + \beta_\tau \left(Treat_c \times \alpha_\tau \right) \right] + \gamma_c + \gamma_t + \varepsilon_{ct}, \tag{1}$$

where Y_{ct} is the average outcome variable for births occurring to women residing in county c and time t, and α_τ is the year relative to (the treatment county's) loss of services. $Treat_c$ is an indicator equal to 1 for counties that experience a loss of hospital-based maternity services, γ_c are county fixed effects, γ_t are calendar time fixed effects, and ε_{ct} is an error term. Standard errors are clustered at the county level.

The coefficients of interest are β_τ, which represent the treat-control differences in outcome Y at event time τ. I omit $\tau = -1$, so each β_τ represents the treat-control difference at event

[9] Median household transfers is not available for independent cities in Virginia. Treated counties in Virginia are matched to potential control counties in Virginia based on all other characteristics. The results are robust to alternative matching specifications (e.g., matching on fewer variables, matching on binned categories of variables, and unrestricted matching within the state). I also ensure each potential control is not associated with more than one closure county. Appendix Table A2 assesses the balance between treatment and control counties following the matching procedure.

time τ, relative to the same difference at event time -1. I focus on the β_τ coefficients from event time -6 to 6, where the treatment and control counties are fully balanced. Effects from event time $\tau < -6$ and $\tau > 6$ are accumulated and the coefficients are not reported.

When presenting the results, I typically plot all β_τ coefficients to observe both pre-trends and the evolution of treatment effects through time. In addition, I summarize the treatment effects by reporting the post-period average of the β_τ coefficients (i.e., $\overline{\beta}_\tau = \frac{1}{7}\sum_{\tau=0}^{6} \beta_\tau$), which represents the average treatment effect in the post period. I also report an early treatment effect (β_0) and a late treatment effect (β_5).

3.3 Identification

The identifying assumptions underlying my estimation strategy are as follows: First, both closure and non-closure counties had similar time trends before the treated county's loss of service. Second, in the absence of the loss of service, closure counties would have continued to follow the same trends as those in the non-closure counties.

Under these assumptions, I interpret the β_τ coefficient as the causal effect of losing maternity services on outcome Y. Importantly, identification of this causal effect comes from differences between the closure and non-closure counties. Thus even though the closures themselves are occurring at different calendar times, the effects are estimated as differences between treated and control counties rather than solely leveraging variation in timing.

One concern with the identifying assumptions underlying this empirical strategy is that areas that experience a loss of hospital-based maternity services are different from areas that do not. For example, a county that loses access to maternity services may be on a declining economic path, and this may create a fundamental difference in the type and health of the women residing in that county. Matching on observables helps address this concern by ensuring that treatment and control areas have similar demographic and economic characteristics prior to the closure. In addition, I plot the coefficients from estimates of Equation (1) to assess the presence of pre-trends. To assess potential changes in composition, I estimate Equation (1) using the log of the number of births occurring to residents of a closure county (i.e., fertility) and various demographic characteristics. The results, presented in Appendix Figure A1, do not suggest any changes in fertility or composition.

A related concern is that the control group is selected from the set of counties that always provide maternity services. In particular, areas that continually provide maternity services may be on a different trajectory because they start out larger and more economically connected relative to counties that close their maternity services. I address this concern by checking robustness to the choice of control group using two alternative control groups. In the first, I select control counties from the set of counties that never provided maternity care from 1996 to 2018, seen in Appendix Figures A2 to A4. In the second, I split each state into "early closures" and "late closures," where the late closures close at least 4 years after the early closures, seen in Appendix Figures A5 to A7. I prefer the control group chosen in the main specification since it maximizes the sample of closure counties and avoids the possibility of a control county being treated before my sample period. Nevertheless, my results are robust to both alternative control groups.

Another threat to the identifying assumption would be the presence of a shock that impacts closure areas, and not control areas, occurring at the same time as the closure. Since most major health policy decisions occur at the state level (rather than a county or zip code level), I mitigate this concern by restricting matches to be nonadjacent counties within the same state. The differences in calendar time of closures as well as the within state matching make it unlikely that the effects are driven by the treated areas experiencing a concurrent shock unrelated to the hospital closure.

4 Main Results From Rural Closures

4.1 First Stage

I first consider the "first stage" impact of the closure on the number of births occurring in the county. Following the closure, births occurring within the county should drop to zero. Since the county no longer offers maternity services, nearly all women living in the county should give birth in a county other than their county of residence.[10] Figure 4 plots the treat-control differences from estimating Equation (1) with the number of births occurring in a county (Panel (a)) and the number of resident births occurring out of county (Panel (b)) as the dependent variables. The figure in Panel (a) is the regression equivalent of Figure 2.

Closure counties had a sizable number of births before closure. Two years before closure, closure counties had an average of 120 births occurring within the county. In addition, births were already decreasing (though slowly) from years -6 to -2 before closure. There is a larger drop in births in the year before closure, due to closures happening at different points during this year. Following the closure, there is a significant drop in the number of births occurring within the closure county, as expected. Even before closure, more than two-thirds of women were bypassing their local hospital and giving birth outside of their county of residence. This suggests that the perceived benefit (i.e., higher quality doctors or hospitals) of the out-of-county hospital outweighed the cost of increased travel distance for a majority of women. Nonetheless, the share of births occurring out-of-county rises significantly and indicates that after closure nearly 100 percent of births occur out-of-county for women residing in a treatment county. The results for this subsection, and the two that follow, are summarized in Table 3.

[10]Note that there could still be a small number of births occurring within the county if women give birth out-of-hospital or in a hospital that no longer provides maternity services (i.e., deliver in the emergency room).

4.2 Infant Health

When a maternity ward closes, women have to travel farther distances for delivery. The increase in travel distance in rural areas is likely to be large, as discussed in Section 2. The increase in travel distance could negatively impact infant health if there are reductions in prenatal care or increases in out-of-hospital births. Pregnancies with limited prenatal care and out-of-hospital births could lead to complications and negative impacts on infant health (Moore et al. (1986), Twizer et al. (2001), Vintzileos et al. (2002), and Grünebaum et al. (2020)). In this section, I investigate if the closures have any impact on various measures of infant health.

There are no clear trends that would suggest a negative impact on infant health. Figure 5 plots the treat-control differences from estimating Equation (1) using share of births that are low birth weight (less than 2500 grams), share of births with an Apgar score below 7, share of births preterm (less than 37 weeks gestation), and the infant mortality rate as the dependent variables. I can rule out relatively small deleterious effects on low birth weight, Apgar scores, and preterm birth. I can reject increases in low birth weight of more than 2.9 percent, increases in the share of births with a low Apgar score of more than 11.4 percent, and increases in preterm birth of more than 1.5 percent. Due to the small baseline infant mortality rate, I cannot rule out even relatively large increases in infant mortality. However, the fairly precise null effect on other outcomes provides reassuring evidence that the reduction in Cesarean births did not harm infants.

4.3 Outcomes of Pregnancy and Birth

Maternity would closures could indicate potential threats to maternal health if they increase out-of-hospital birth or reduce prenatal care, even in the absence of negative effects to infants. In addition, maternity ward closures could impact medical interventions during delivery, such as induction or Cesarean birth. This section explores the impact of closures on these channels.

The increased distance to a hospital may result in out-of-hospital births if, for example, women are unable to reach the hospital in time and deliver unintentionally at home or while en route to the hospital, which is riskier than a planned hospital birth.[11] Panel (a) of Figure 6 plots the treat-control difference in the share of births in the matched sample that take place outside of a hospital. Out-of-hospital births are an incredibly rare event in the United States, with less than 2 percent of births occurring outside of a hospital. However, contrary to the concern regarding increased travel distances and out-of-hospital birth, women residing in closure counties do not experience a statistically significant increase in the share of births occurring outside of a hospital following the closure of a maternity ward, relative to the same difference for women residing in the matched control counties.

Even before delivery, the increased travel distance can impact maternal outcomes through decreased utilization of prenatal care. When a county loses its maternity ward, the women in the county may also lose their access to prenatal care if the obstetricians relocate to other areas or if prenatal care was provided in the hospital. Panel (b) of Figure 6 plots the treat-control differences in the share of pregnancies with no prenatal care. Though imprecisely estimated, there is a positive difference between counties that experience a closure and the matched control counties that do not experience a closure in the post-period. Having no prenatal visits is a fairly rare occurrence, with less than 1 percent of births in control counties meeting this designation in the period prior to closure.[12]

To avoid potentially lengthy drives to the closest hospital with a maternity ward during active labor, women may elect to have an induction. Elective inductions can usually be scheduled at 39 weeks gestation and are associated with a decreased risk of Cesarean birth in post-term deliveries past 41 weeks of gestation. However, earlier inductions may be associated with an increased risk of Cesarean birth (Caughey et al. (2009)). This association

[11] While some studies find no adverse impact of planned home births, there is evidence that home births in the United States are more dangerous and result in higher mortality compared to a hospital birth than is seen in countries that have more integrated midwifery systems (Grünebaum et al. (2020)).

[12] Other cutoffs for prenatal care (e.g., less than 2 or 6 visits) also show small and noisily estimated increases.

between inductions and Cesarean births has been coined the "cascade of interventions": labor is induced and the birthing process is increasingly medicalized, ultimately resulting in a Cesarean delivery.

There is a rise in the share of births induced in treatment counties even before closure, starting as early as three years prior to closure. Panel (c) of Figure 6 provides evidence *against* the notion that women choose to have an elective induction following closure. The figure shows that the rate of inductions does not increase relative to the increase seen in pre-closure years and, if anything, the rate of increase in inductions actually slows down.

The ultimate result of the "cascade of interventions" is a Cesarean delivery. Since inductions did not increase because of closure, Cesarean births should not increase as a result of the "cascade." Panel (d) of Figure 6 indicates that the treat-control differences in the share of births delivered via Cesarean in the pre-period are stable and small, suggesting the parallel trends assumption is valid. The post-period treat-control differences are significantly negative. The share of births delivered via Cesarean decreases for women residing in closure counties by approximately 2 percentage points following closure, relative to the same difference for women residing in matched control counties, which is roughly a 6 percent decrease. Taken together, Panels (c) and (d) provide evidence against the "cascade of interventions". Following closure, induction does not increase and the Cesarean rate decreases. I present results weighted by the number of births for this and the prior 2 sections in Appendix Figures A8 to A10, and the results are similar.

The results of this section suggest that, though the increase in travel distance in rural areas is relatively large, there are no adverse impacts of closure for women in terms of increases in out-of-hospital birth or reductions in prenatal care. Closures are associated with a reduction in Cesarean deliveries. I explore the reductions in Cesareans, and whether it has a positive or negative impact on women, in Section 5.

5 Analysis of Reduction in Cesarean Birth

The results from the main analysis suggest that the closure of a rural maternity ward reduces Cesarean deliveries for women residing in closure counties. Since Cesarean delivery carries a greater risk of severe maternal morbidity, the reduction in Cesarean deliveries could be a benefit of closure if it reduces unnecessary procedures. However, the reduction could be a cost of closure if it reduces Cesareans among women who cannot safely deliver vaginally. To investigate this, I study whether the decrease in the rate of Cesarean births occurs among high- or low-risk women. In addition, I explore the role of provider delivery practices in explaining the reduction in Cesarean births.

5.1 Results by Maternal Risk Factors

A Cesarean birth is a major surgery. As with other surgeries, Cesareans come with serious risks, such as infection, hemorrhage, and blood clots. In addition, Cesareans also have the potential to create long-term effects, such as damage to reproductive organs. A Cesarean birth in one pregnancy often leads to future Cesarean births, with more than three-quarters of women with a history of Cesarean birth having a repeat Cesarean with future births (Osterman et al. (2020)). However, a Cesarean birth can also be a life-saving surgery and allow an infant to be born safely when a vaginal birth is otherwise unsafe. To minimize the potential risks and maximize the benefits, Cesareans should be performed only on women and infants who would face worse outcomes if delivery were to occur vaginally.

Since I cannot determine how women would have fared in their counterfactual delivery, I instead investigate if the reduction in Cesarean births occurs among both high- and low-risk women. If women who are observably high-risk experience a reduction in Cesarean deliveries following the maternity ward closure, the closure is impacting women for whom the costs of not receiving Cesareans are very high. On the other hand, if reductions are concentrated among women for whom Cesareans are less appropriate, this could suggest that unnecessary

Cesareans have been reduced. In particular, ACOG highlights the rapid increase in Cesarean deliveries since the 1990s as evidence that Cesarean births may be overused among low-risk women (ACOG (2014)).

To assess risk levels, I follow Currie and MacLeod (2017) and estimate the following logistic model:

$$\text{Prob}\,(C_i = 1) = F(\beta X_i), \tag{2}$$

where C_i is an indicator if the birth was delivered via Cesarean and X_i are purely medical observable risk factors available consistently in the birth certificate data. The inputs used in the logit regression are mother's age, birth order, previous Cesarean, plurality of birth, breech presentation, blood pressure disorders (eclampsia, chronic hypertension, and gestational hypertension), and diabetes. I estimate the model on all births in the closure counties and the corresponding matched control counties.

The distribution of the estimated propensity scores, which can be viewed as the "appropriateness for a Cesarean," is displayed in Figure 7. The figure shows that most women who do not deliver via Cesarean have a propensity score below 0.30. For women who do deliver via Cesarean, there is a lot of mass both above 0.80 and below 0.30, highlighting that a considerable number of women with minimal observable risk factors nevertheless receive a Cesarean.

I investigate how the reduction in Cesareans changes by the appropriateness for a Cesarean in Figure 8. Based on the distribution of Figure 7, I split women above and below the 0.30 cutoff based on their propensity scores derived from estimating Equation (2). I then re-estimate Equation (1) separately for both high- and low-risk women. Figure 8 plots the treat-control difference in the share of births delivered via Cesarean for both groups. The coefficients for the low-risk women (the women least appropriate for Cesarean birth) are displayed in Panel (a), and for the high-risk women in Panel (b). The results from these figures are summarized in Table 4.

The decrease in the share of births delivered via Cesarean is only visible for women with low levels of risk. These women are the least appropriate candidates for a Cesarean, with an estimated propensity score of less than 0.30. The average post-period coefficient of -0.016, as seen in Table 4, indicates that closure is associated with a reduction in the rate of Cesarean birth of roughly 1.6 percentage points. With a Cesarean rate of 16.4 percent for low-risk women, this represents a 10 percent decrease. High-risk women, on the other hand, do not experience any reduction in Cesarean births, as seen in Panel (d) of Figure 8.

Since the reduction in Cesarean births is driven by low-risk women, the decrease in Cesarean births can be viewed as a benefit of closure. It would be worrying if the decrease was concentrated among the riskiest women, but this is reassuringly not the case. While I am unable to study outcomes such as maternal morbidity or mortality due to data limitations, I view the reduction in Cesarean births as a benefit since the reduction is concentrated among low-risk women and there are no adverse outcomes for infants.

5.2 Impact of Provider Practice

A potential explanation for the reduction in Cesarean deliveries could be that providers in the hospitals that close have a higher propensity to perform Cesareans. There is considerable variation in the use of Cesarean birth across hospitals, ranging from 19 percent to 48 percent (Card et al. (2019)). If women are shifted from hospitals with a high Cesarean rate to hospitals with a low Cesarean rate, there could be a reduction in Cesarean deliveries due to exposure to different provider practices.

I begin by identifying what county women who experience a closure deliver in following closure. Since women may decide to give birth in any county following closure, there could be several potential "receiving" counties. To have one receiving county per closure county, I determine the most impacted receiving county using the following method. For each closure county, my possible set of receiving counties are the counties that have at least one birth from the closure county in each year following closure. I define the receiving county to be the one where the closure women make up the largest share of births occurring in the receiving county over the post-period.

To investigate if closure counties perform relatively more Cesareans, I plot the raw rates of Cesarean birth in closure and receiving counties leading up to the closure of the maternity ward in Figure 9. Panel (a) plots the average Cesarean rate in a closure county and in a receiving county leading up to closure. Panel (c) plots the average Cesarean rate among low-risk women (i.e., women with a propensity score of less than 0.30) in a closure county and in a receiving county leading up to closure, while Panel (e) plots the Cesarean rates among high-risk women. Panels (b), (d), and (f) illustrate the same comparisons while weighting by the number of births occurring in a county.

Closure counties perform significantly more Cesarean births when weighting by the number of births occurring in a county, though there is no significant difference in the rate on average. In addition, the gap between closure and receiving counties widens over the pre-closure years, stemming from an increase in the Cesarean rate among low-risk women. While the primary results are not sensitive to weighting, some counties have relatively few Cesarean births and thus bring down the overall average Cesarean rate without weighting.

To investigate the role of provider practice, I split my sample into three groups: (1) receiving county has a higher rate of Cesarean birth, (2) receiving county has a lower rate of Cesarean birth, and (3) receiving county has an approximately equal rate of Cesarean birth. To create these three groups, I first calculate the difference in the pre-closure rate of Cesarean births occurring in the closure and receiving counties. I then split this difference into terciles. The group where the receiving county has a higher rate has an average difference of 12.2 percentage points (range: 3.3 to 38.6 percentage points). The group where the receiving county has a lower rate has an average difference of -10.7 percentage points (range: -3.4 to -57.0 percentage points). The group where the closure and receiving county have approximately equal rates has an average difference of 0.0 percentage points (range: -3.4 to 3.3 percentage points). I re-estimate Equation (1) separately on each of the three groups.

I find the strongest reductions in Cesarean births when women shift from areas with a high rate of Cesarean births into areas with a low rate of Cesarean births. The point estimates for each tercile are shown in Figure 10 and summarized in Table 5. In Panel (a), where women are shifted from areas with high Cesarean rates to areas with low Cesarean rates, the average post-period coefficient of 0.030 suggests maternity ward closure is associated with approximately a 3.0 percentage point (9 percent) decrease in the rate of Cesarean birth following closure, relative to the matched control counties. I do not find as strong of a decrease in the other groups. In fact, I do not find any decrease when women shift to an area with a higher utilization of Cesarean births, as seen in Panel (c). The results from this section suggest that provider practice is important. Cesarean rates decrease the most for women residing in counties that have a higher rate of Cesarean birth before closure relative to the receiving county.

6 Additional Results on Rural Closures

6.1 Results by Access to Care

My results show that rural maternity ward closures do not lead to negative effects on health outcomes. To reconcile my null results with the concerns presented in the media, I perform a heterogeneity analysis looking at differential access to alternative maternity care. There may be negative effects of hospital closures in more remote areas where travel time to the nearest alternative is high.

To study if outcomes vary between more and less remote areas, I first determine what options women have following the maternity ward closure. I use two definitions of available alternatives since I am unable to observe a woman's exact residence in the birth certificate data. In the first measure, I use the AHA Annual Survey to determine how many hospitals provide maternity care in the counties surrounding the county that experiences a closure. In the second measure, I estimate the average distance a woman in a closure county would need to travel to the next closest hospital with a maternity ward. To do this, I use the center of population calculated by the U.S. Census Bureau based on the 2000 Census to get the population-weighted centroid of a closure county. I then calculate the travel distance to the nearest maternity ward using the hospital location information provided in the AHA Annual Survey.

I split the sample at the median level of access and estimate Equation (1) separately on counties above and below median. Results for selected outcomes are displayed in Figure 11 and summarized in Tables 6 and 7. The remaining outcomes are available in Appendix Figures A11 to A13. The definition of access in panels (a), (c), and (e) is the number of hospitals with a maternity ward in adjacent counties, and in panels (b), (d), and (f), I define it as the distance to the nearest hospital with a maternity ward.

Before closure, a majority of women in both groups gave birth out-of-county. In more remote areas. If there are not as many good options nearby, a woman may be more inclined to stick with her local hospital. On the other hand, a closure county that has more access to alternatives would likely have higher levels of out-of-county births before closure. If a woman does not need to travel very far or has many outside options, it will be easier for her to bypass her local hospital. If more women give birth in-county before closure, a maternity ward closure could have a larger impact compared to areas where less women give birth in-county. The dependent variable in panels (a) and (b) of Figure 11 is the share of births occurring out-of-county. In the period before closure, around 74 percent of women in low access areas gave birth out of county compared to 79 percent of women in high access areas. Interestingly, even if there are not as many nearby options, a majority of women are still bypassing the local hospital.

When access to alternatives is more extremely limited, women may give birth out-of-hospital, either by choice (for example, a planned home birth) or by accident (for example, because she did not make it to the intended hospital in time). Panels (c) and (d) plot the treat-control difference for the share of births occurring out-of-hospital. The plot provides support for limited access leading to out-of-hospital births: closure is associated with an increase in out-of-hospital births for women with below-median access to alternatives. The same is not true for women with above-median access to alternatives. For women with an above-median travel distance to the next nearest maternity ward, the average post-period coefficient of 0.004 suggests that closure is associated with a 0.4 percentage point increase in out-of-hospital births, relative to a mean of 0.9 percent in the period before closure.

Since rates of Cesarean births significantly decreased in the baseline results, I plot the treat-control differences for Cesarean births by access levels in panels (e) and (f). When access is defined as the number of options in adjacent counties (Panel (e)), the decrease in Cesarean births is driven by areas with below-median access to alternatives. In Panel (f), where access is defined as the distance to the nearest maternity ward after closure, neither group seems to be particularly driving the decline. Taken together, these results suggest that, if anything, the reduction in the rate of Cesarean births is coming from areas with less access to alternatives. These results align with the results on provider practice. In Panel (e), the below-median access counties have a higher rate of Cesarean births and therefore have more scope for being shifted to a county with a lower rate. In Panel (f), the rate of Cesarean births is roughly equal across groups, as is the reduction in Cesarean births.

6.2 Effects of Closure on Receiving Women

Having established the baseline impacts on women residing in the closure counties, I now turn to another potentially impacted group: women residing in the receiving counties. Women residing in the receiving counties could be impacted if the closure of a nearby hospital results in overcrowding, which could negatively impact the quality of care. However, as discussed in Section 2, this channel is likely to be small for rural closures since the number of births in a hospital before closure is relatively small. The results from estimating Equation (1) on the sample of receiving counties and their controls are summarized in Table 8. Detailed regression plots are available in Appendix Figures A14 to A16.

The "first stage" impact of closure on receiving women should indicate that following closure, births increase in the receiving counties due to the inflow of women from the closure county. As expected, the increase in births relative to the pre-closure number of births in the receiving areas is very small and is unlikely to generate overcrowding or any other negative spillover effects. The results indicate that there is no overcrowding in the receiving counties. Out-of-county and out-of-hospital births could increase, and utilization of prenatal care could decrease, if receiving women were faced with more strained hospitals. However, the point estimates are small and insignificant, suggesting no effect. In addition, I find no impacts on the remaining outcomes for pregnancy or infant health.[13] The results of this section show that the rural closures can be easily absorbed into the surrounding areas with little impact.[14] I look at the impact of urban closures in Section 7.

6.3 Results by Subgroup

Maternal and infant health in the United States lags other peer countries. Within the United States, disparities in maternal and infant health exist along racial, ethnic, and socioeconomic lines. For example, the infant mortality rate for Black infants in 2018 was 10.8 per 1,000 live births, compared to 4.6 for non-Hispanic white infants (Ely and Driscoll (2020)). Maternity ward closures also disproportionately occur in counties with higher proportions of non-Hispanic Black women and lower median household incomes (Hung et al. (2017)).

In this section, I investigate if the loss of maternity services exacerbated any existing maternal and infant health disparities by looking at results across various subgroups. I look at heterogeneity by race and ethnicity (non-Hispanic Black and Hispanic), education (high school or below and more than college), and age (under 20 years old and more than 35 years old). I estimate Equation (1) on the sample of births in a county of the specified demographic characteristic, ensuring the analysis sample is fully balanced by dropping treat-control county pairs that lose balance in the subsample. The post-period average treat-control differences

[13] While Table 8 suggests a reduction in Cesarean births, an analysis of the regression plots suggests this reduction is driven by pre-existing trends.

[14] Even when looking at the "most impacted" areas (i.e. the areas where the closure women make up the largest share of births), I still do not find any impact of closure.

are summarized in Table 9, and the full regression plots are available in Appendix Figures A17 to A24.

Looking across the different samples, no demographic subgroup is particularly impacted by the maternity ward closures. The results for most demographic groups are consistent with the results found on average. All groups except women older than 35 years experience a reduction in Cesarean deliveries. This aligns with the analysis of the Cesarean results by risk level in Section 5.1. Advanced maternal age is considered riskier than births in the 20 to 34 age range, with a higher prevalence of obstetric complications, maternal morbidities, and adverse infant health outcomes (Lisonkova et al. (2017)).

7 Impacts of Urban Closures: The Texas Case

In the previous sections, I identified county-level closures in rural areas. There could, however, be different impacts of closures in urban areas. As discussed in Section 2, the scope for detrimental effects of closure due to the costs associated with increased travel distance are much more limited in urban areas. On the other hand, urban closures have the potential for larger spillover effects due to a greater quantity of displaced women. To investigate if maternity ward closures have different impacts in urban areas, I turn to my dataset of urban closures in Texas.

7.1 Empirical Strategy

I follow a similar empirical strategy as in the main analysis on rural closures, employing a matched difference-in-differences design. I calculate the distance from a zip code's centroid to the nearest hospital providing maternity services in each year. Women residing in a zip code that experiences an increase in the distance to the closest hospital with maternity services between 2005 and 2008 serve as the treated women in the analysis. Women residing in a zip code that does not experience an increase in the distance to the closest hospital with maternity services from 2000 to 2014 serve as the potential control group. I restrict matches to be in non-adjacent counties within the same public health region. I use propensity score matching and match on population, median household income, unemployment rate, population, share Black, share Hispanic, and share female aged 15 to 44.

I run a similar specification for the urban closures as the specification for rural closures in Equation (1). I shorten the pre- and post-period to four years (rather than six) because I have data for fewer years. I run the following specification:

$$Y_{izt} = \sum_{\tau=-4}^{\tau=4} \left[\theta\tau\alpha_\tau + \beta_\tau \left(Treat_z \times \alpha_\tau\right)\right] + \gamma_z + \gamma_t + \varepsilon_{izt}, \tag{3}$$

where Y_{izt} is the outcome variable for woman i residing in zip code z giving birth in calendar year t. α_τ is the year relative to closure in the (treated) woman's zip code of residence. $Treat_z$ is an indicator equal to 1 for women residing in zip codes that experience a change in distance to a hospital providing maternity services. γ_z are zip code fixed effects, γ_t are calendar time fixed effects, and ε_{izt} is an error term. Standard errors are clustered at the county level.

7.2 Maternal Outcomes

Urban closures are unlikely to result in large increases in travel distance given the density of other options. Since the change in travel distance is minimal and the quality differences may be small, the impacts of a maternity ward closure in an urban area are likely to be small. Consistent with this notion, I do not find any impact on the closure women, as seen in Figure 12. The dependent variables are indicators for whether a birth was delivered via Cesarean (Panel (a)), whether a birth was induced (Panel (b)), whether the length of stay was more than 3 day (Panel (c)), and whether any diagnosis or procedure code indicates severe maternal morbidity (Panel (d)). In each panel, closure is not associated with any significant change in maternal outcomes. In addition, I do not find any difference between large and small closures measured by the number of births before closure, as seen in Appendix Figures A25 and A26.

In contrast to the closure women, it is plausible for the closures to have larger impacts on the receiving women due to the number of displaced women and the potential for overcrowding at the surrounding hospitals. I define receiving women as the women whose closest hospital is the one where most treated women go following closure. The results, displayed in Figure 13, show that closure is associated with an increase in the likelihood of a Cesarean birth for receiving women.

Finally, I study how closure impacts receiving women who are more "exposed" to the closure women. To determine the exposure to closure women, I look at the number of births per bed. I take the total births at the receiving hospital and divide by the number of beds. To avoid the endogenous choice to increase the number of beds in response to the inflow of closure women, all post-period years use the number of beds in the year before closure when determining the number of births per bed. I take the difference between the 2-year average immediately post-closure and the 2-year average immediately pre-closure and I split this difference at the median. Hospitals with above-median exposure experience the largest increase in births per bed, which can be viewed as the strain on the hospital due to the inflow of new women. The above-median hospitals have an average increase of 15 births per bed.

Women at the hospitals that experience the largest changes in births per bed see larger increases in Cesarean births. Figure 14 displays the results on the sample of women whose nearest hospital is above median exposure. Panel (a) suggests that women residing near the more exposed hospitals have an increase in the likelihood of a Cesarean birth following closure, relative to the matched control women. In Appendix Figure A27, I show the results for women below median exposure and find that the less exposed women do not experience the same increase in Cesarean births.

7.3 Infant Outcomes

Since maternal health for closure women was not impacted, the impact of closure on their infants is likely to be small. I study the impact of closure on infant health outcomes in Figure 15. The dependent variables are indicators for whether length of stay is more than 3 days (Panel (a)), preterm birth (Panel (b)), low birth weight (Panel (b)), and whether the infant dies during the initial hospital stay (Panel (d)). As expected, there is no discernible impact of closure on infant health outcomes in any panel.

Health for infants of receiving women could be impacted in two ways: the potential overcrowding resulting in decreased quality of care or the increase in Cesarean deliveries. The results for infants in all receiving hospitals and in the most exposed receiving hospitals are displayed in Figures 16 and 17. Similar to the newborns of the closure women, the newborns in receiving hospitals are unaffected by the closure. Taken together, the results of the previous two sections suggest that there are no impacts of closures on newborns, but women in receiving hospitals experience an increase in Cesarean delivery.

8 Conclusion

This paper studies the impact of losing access to hospital-based maternity care on health outcomes for women and infants. Advocates argue that increased travel distances harm women and infants by increasing out-of-hospital birth, reducing prenatal care, and increasing elective inductions, resulting in the "cascade of interventions" that ultimately ends in a Cesarean birth. Alternatively, maternity ward closures could benefit women if closures exposure women to higher-quality providers and better-resourced hospitals.

To estimate the causal effect of maternity ward closures on birth outcomes, I employ a matched difference-in-differences design. When studying rural maternity ward closures, I do not find support for the concerns raised above and instead find that closures appear to create a net benefit. I do not find that closures are associated with adverse health outcomes for the infants. In fact, I find relatively precise null effects on low birth weight, Apgar scores, and preterm births. In addition, I find strong evidence against the "cascade of interventions." My results suggest inductions do not increase following closure and the rate of Cesarean births decreases. Local provider practice plays an important role in the decrease in Cesarean births. Women who shift from areas that perform relatively more Cesarean births see the largest reductions. In addition, the decrease in Cesarean births is concentrated among low-risk women, suggesting the closures reduced of unnecessary Cesarean procedures.

While I found gains to closure in rural areas through a reduction in Cesarean deliveries for low-risk women, I do not see the same benefit in urban areas. With urban closures, I find minimal effects on women and infants who experience a closure, while women who are in the receiving hospitals see an increase in Cesarean births. One explanation for this divergence is the difference between closing a small rural maternity ward compared to closing a large urban one. The average number of births occurring in a rural county that closes its maternity ward is around 120, compared to more than 500 in the average urban maternity ward that closes. Since the closures in rural areas impact many fewer women, the closures may be more easily absorbed by the surrounding hospitals.

These results suggest the discussion on "maternity care deserts" may be missing an important component. It is important to have access to high-quality care for rural women, but the maternity ward closures that have naturally occurred in these areas do not have significantly negative impacts on women or children. Most women are bypassing these hospitals and are opting for an out-of-county birth before closure, suggesting that women already perceive the benefits of a different hospital to outweigh the costs of increased travel. Larger hospitals in urban areas are also eliminating maternity wards, potentially disrupting care for women outside the closure hospital due to the larger quantity of displaced women. Since most of the literature has focused on rural closures, further research should investigate the implications of urban maternity ward closures and extend the analysis of urban closures beyond the state of Texas.

The findings of this paper offer several takeaways for policy considerations. Closures are not always negative, and it may not be a worthwhile policy effort to ensure that all hospitals continue to provide maternity services. The rural closures that have naturally occurred have not been detrimental to maternal or infant health. Providing funding to keep rural maternity wards open may not generate returns large enough to justify the cost, and there are likely more effective ways to improve maternal and infant health.

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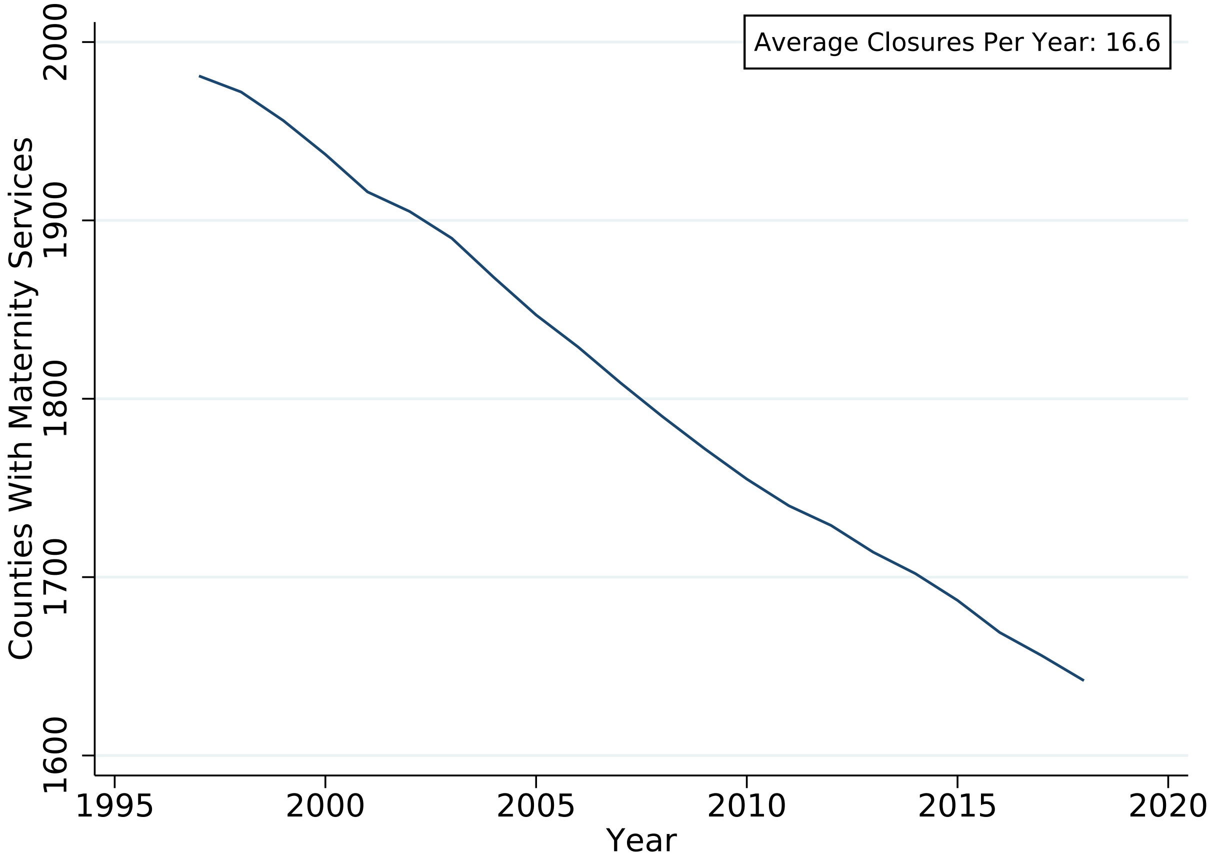
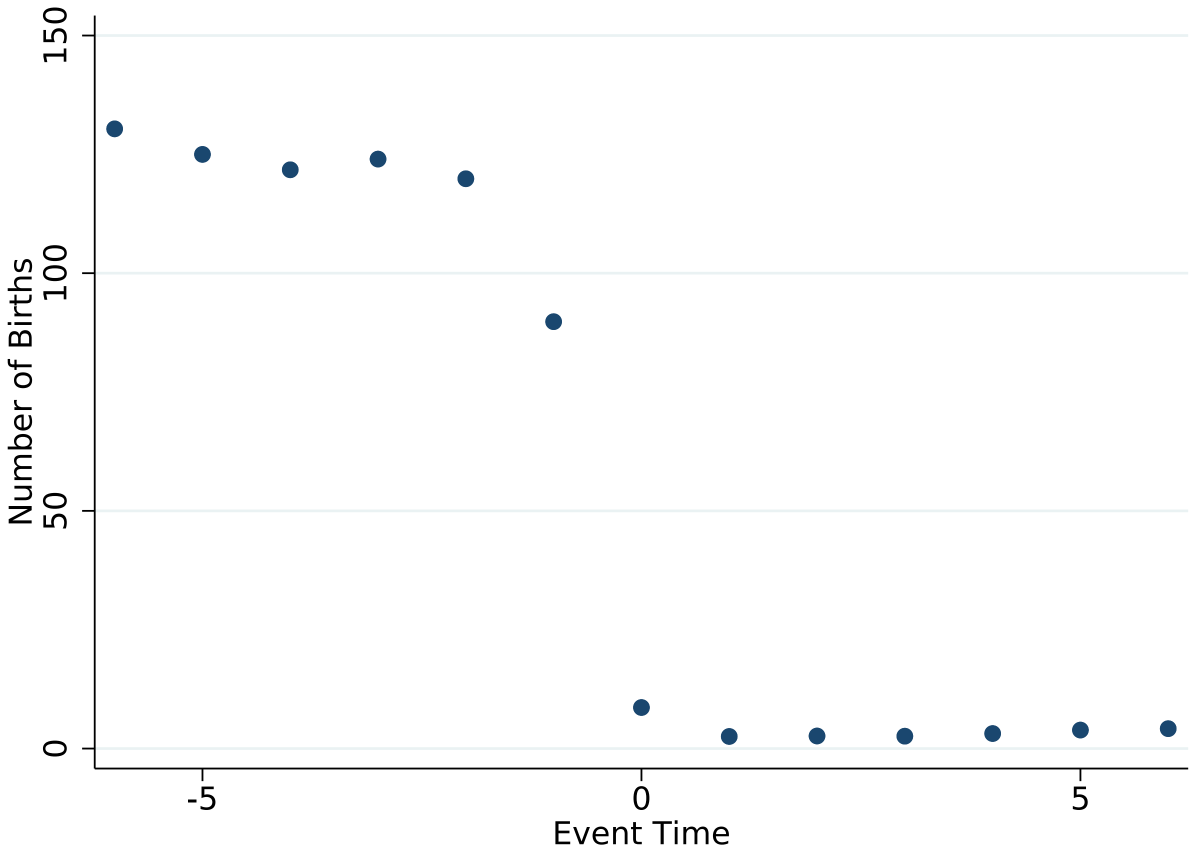
Figure 1: Number of Counties with Maternity Services



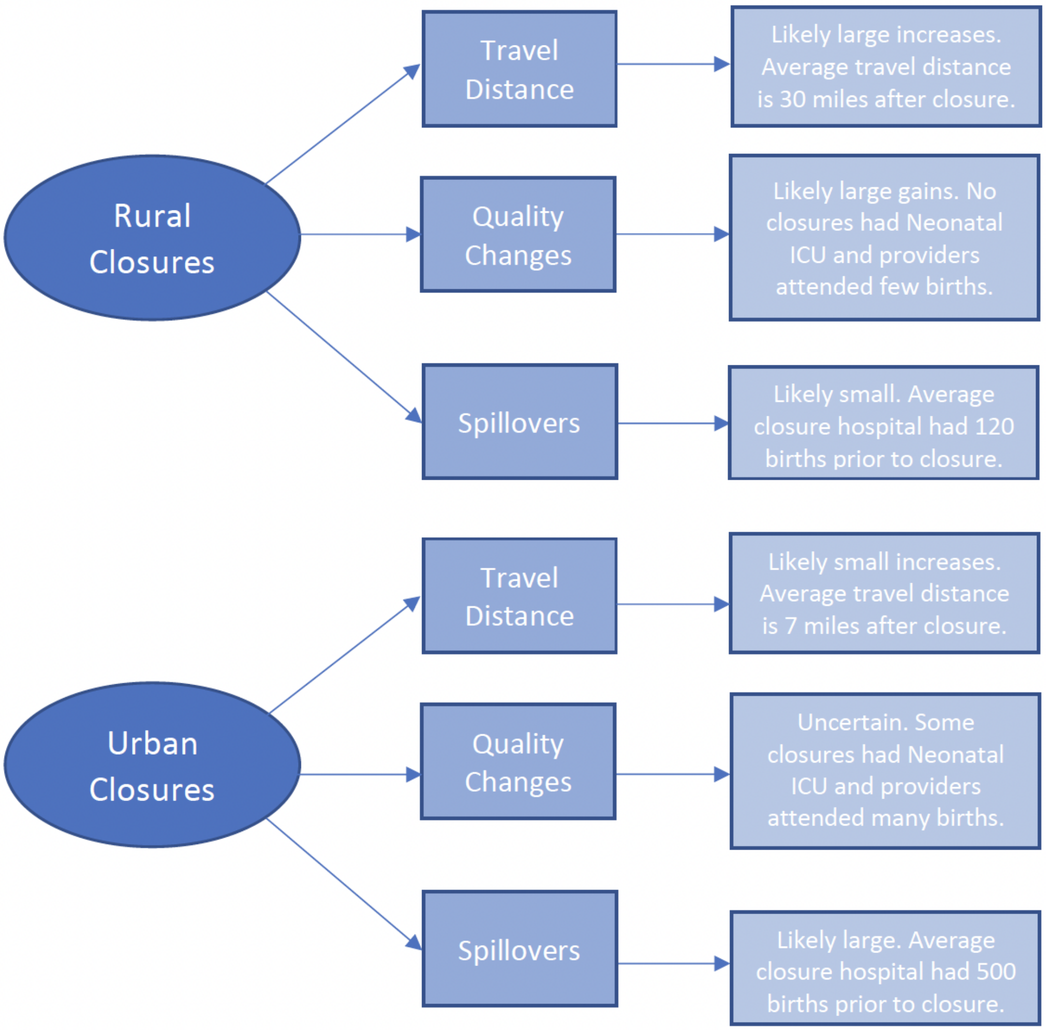
Note: This figure displays the number of counties with maternity services from 1996 to 2018. Counties are identified as offering maternity services based on the presence of hospital births in the county in the Vital Statistics data.

Figure 2: Births Occurring in a County Around Closure



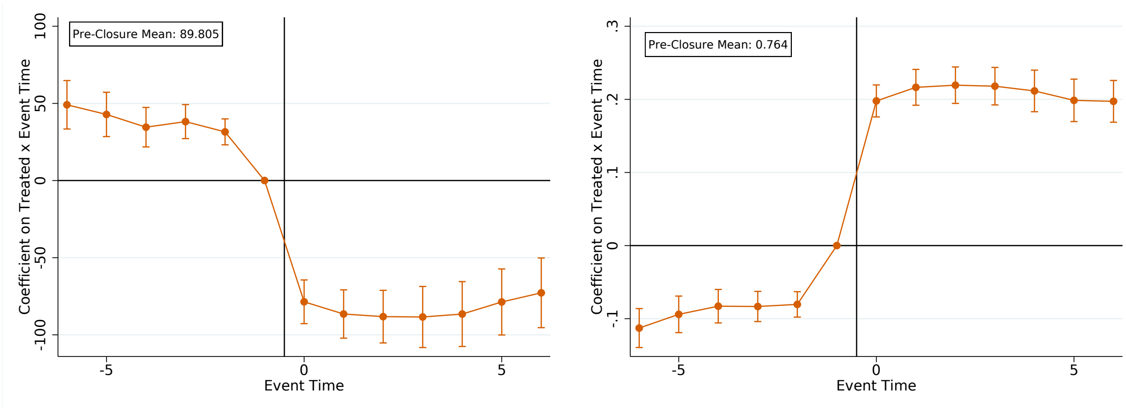
Note: This figure plots the average number of births occurring in a county around the time of a county's identified year of closure. The sample consists of counties that experience a loss in maternity care services between 2002 and 2012.

Figure 3: Potential Impacts of Rural and Urban Closures



Note: This figure summarizes the potential channels through which a maternity ward closure could impact health outcomes. The figure contains details on how the channels are likely to differ in rural and urban areas.

Figure 4: Estimated Impact of Closure on County Births

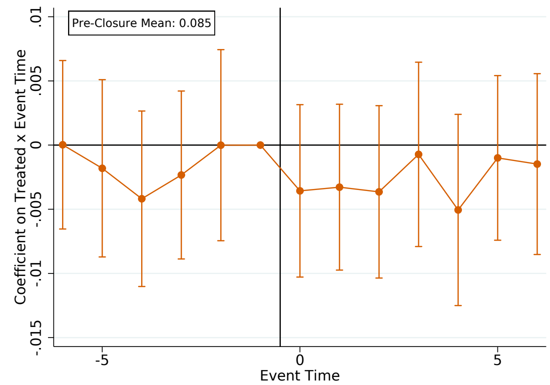


(a) Number of Births in County

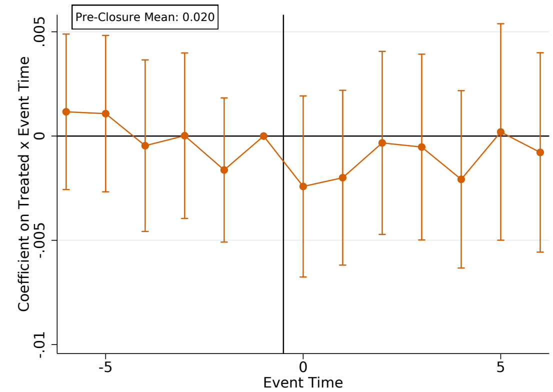
(b) Resident Births Occurring Out of County

Note: In Panels (a) and (b), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (1). The dependent variable in Panel (a) is the number of births occurring within a county at event time τ and in Panel (b) is the share of births occurring to residents of a county occurring outside of the residence county. Observations are at the county-event time level and are clustered at the county level.

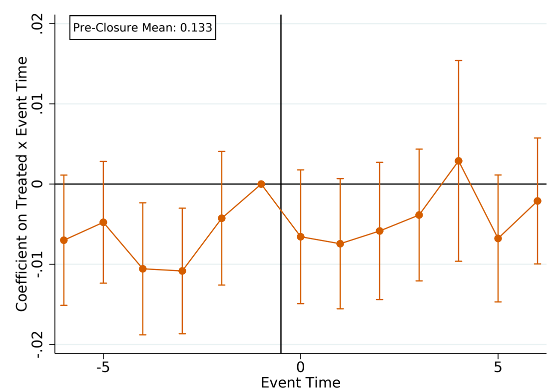
Figure 5: Estimated Impact of Closure on Infant Health



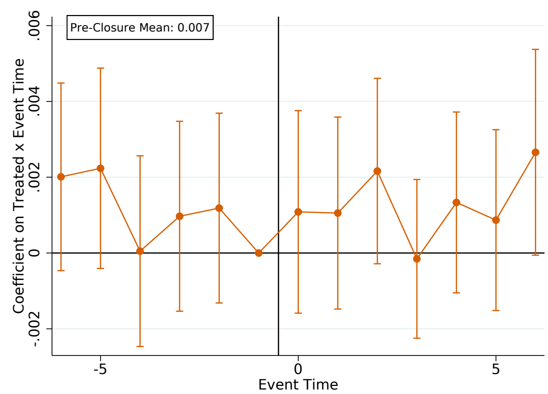
(a) Share of Births Low Birth Weight



(b) Share of Births With Apgar ≤ 6



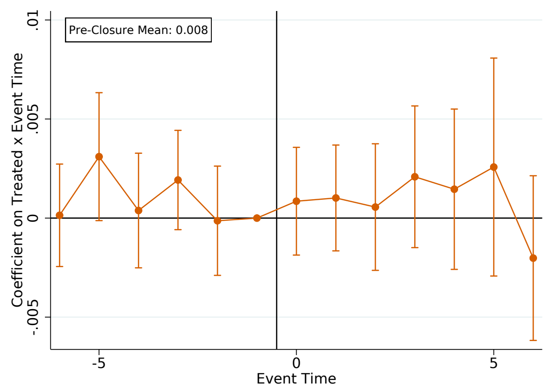
(c) Share of Births Preterm



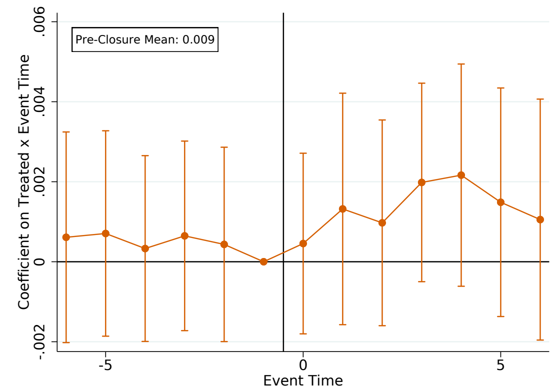
(d) Infant Mortality Rate

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (1). The dependent variable in Panel (a) is the share of births low birth weight (< 2500 grams), in Panel (b) is the share of births with an Apgar score less than or equal to 6, in Panel (c) is the share of births preterm (< 37 weeks gestation), and in Panel (d) is the infant mortality rate. Observations are at the county-event time level and are clustered at the county level.

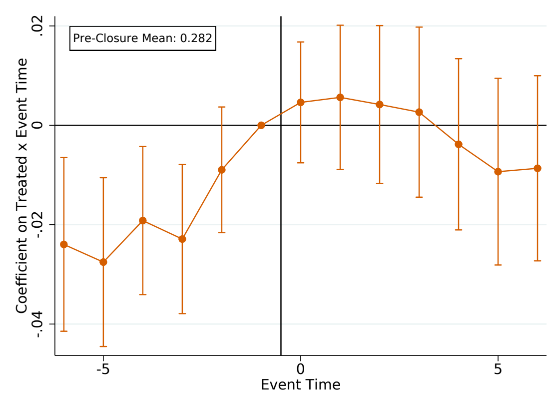
Figure 6: Estimated Impact of Closure on Pregnancy and Birth Outcomes



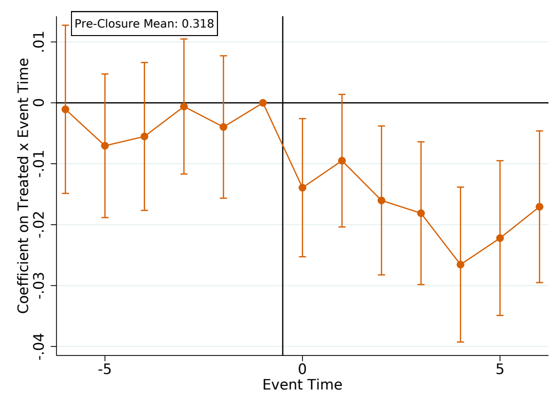
(a) Share of Births Out of Hospital



(b) Share of Pregnancies with 1 or Fewer Prenatal Visits



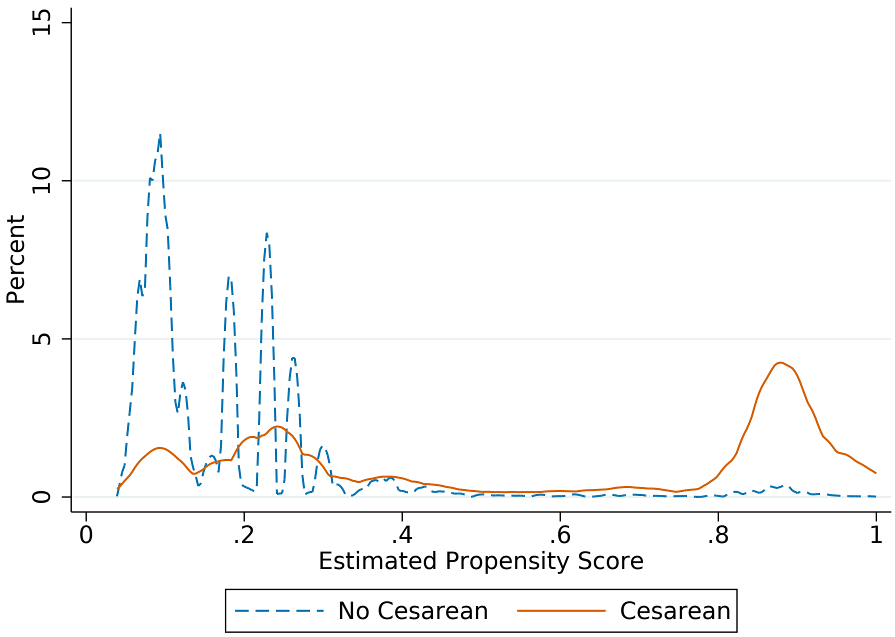
(c) Share of Births Induced



(d) Share of Births Delivered Via Cesarean

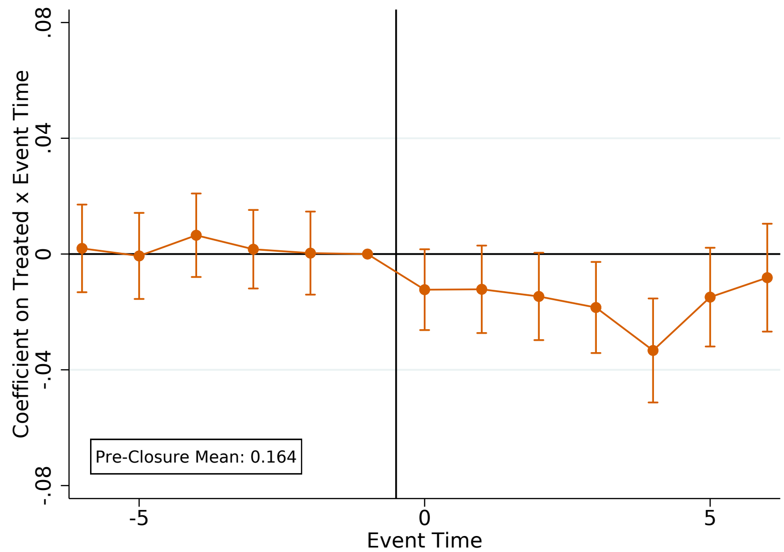
Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (1). The dependent variable in Panel (a) is the share of births occurring outside of a hospital, in Panel (b) is the share of pregnancies with one or fewer prenatal visits, in Panel (c) is the share of births induced, and in Panel (d) is the share of deliveries that occur via a Cesarean. Observations are at the county-event time level and are clustered at the county level.

Figure 7: Distribution of Estimated Propensity Scores by Delivery Method

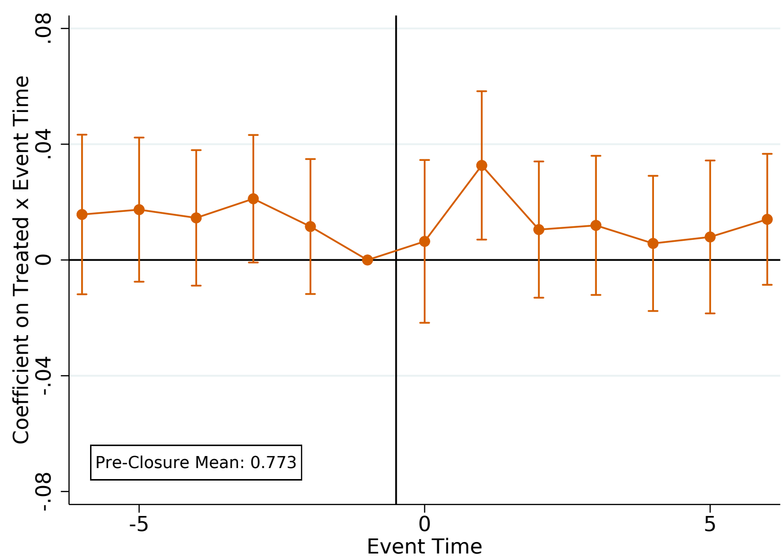


Note: This figure plots the kernel density of the estimated propensity scores from estimating Equation (2) for women who did deliver via Cesarean and for women who did not deliver via Cesarean. The sample consists of all women who reside in the closure and control counties.

Figure 8: Estimated Impact of Closure on Share of Births Delivered Via Cesearean by Pregnancy Risk



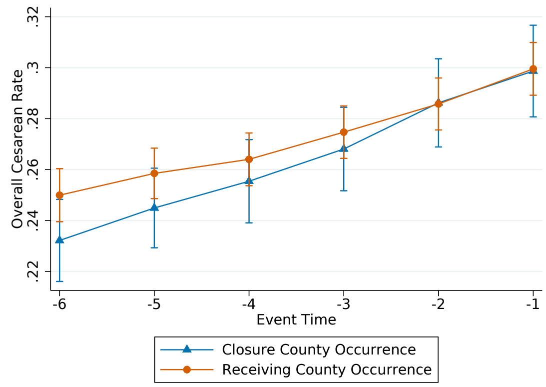
(a) Low-Risk Women



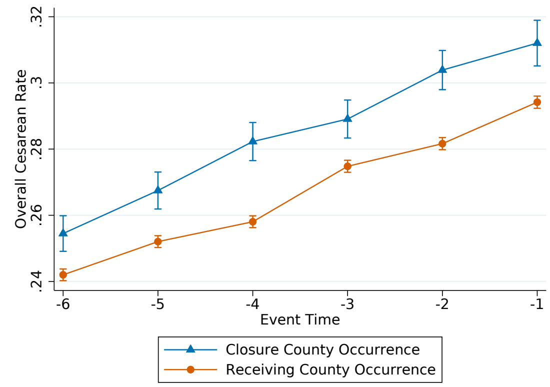
(b) High-Risk Women

Note: In Panels (a) and (b), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (1). The dependent variable in both panels is the share of births delivered via Cesearean. Panel (a) is estimated on the sample of births in a county that falls below a predicted probability of Cesarean (PPC) of 0.30. Panel (b) is estimated on the sample of births in a county that falls above a PPC of 0.30. Observations are at the county-event time level and are clustered at the county level.

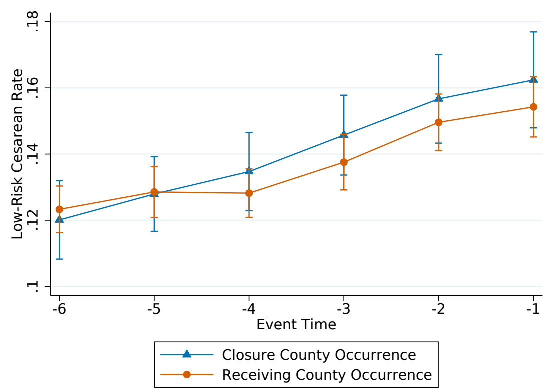
Figure 9: Rate of Cesarean Sections in Closure and Receiving Counties



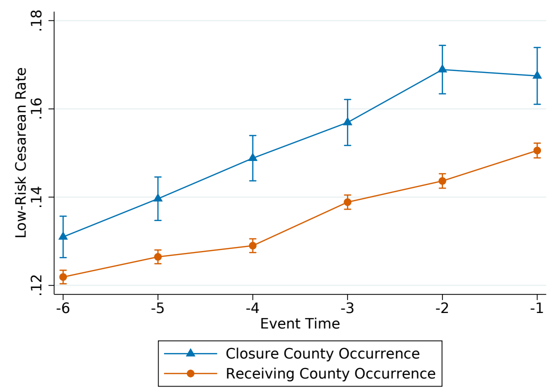
(a) Cesarean Rate



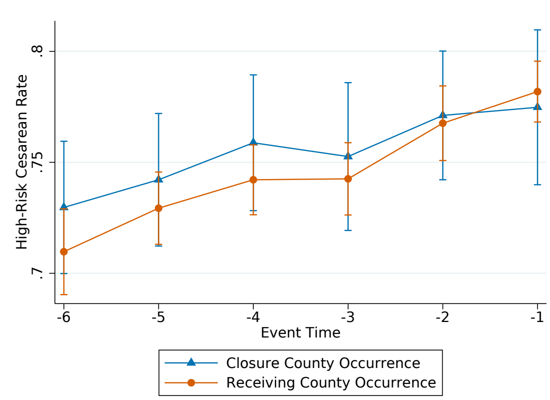
(b) Cesarean Rate, Weighted By Births



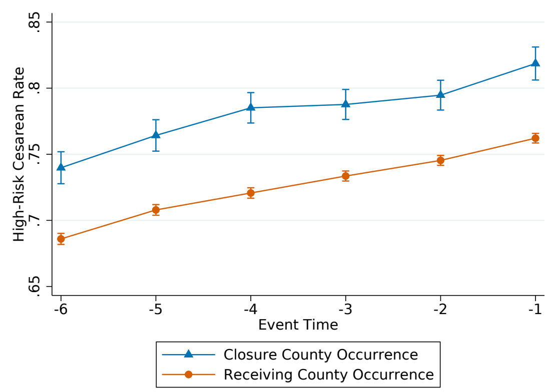
(c) Low-Risk Cesarean Rate



(d) Low-Risk Cesarean Rate, Weighted By Births



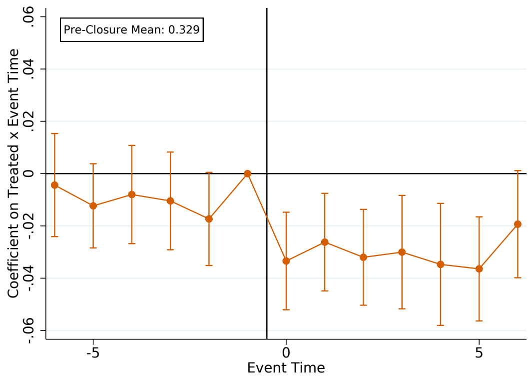
(e) High-Risk Cesarean Rate



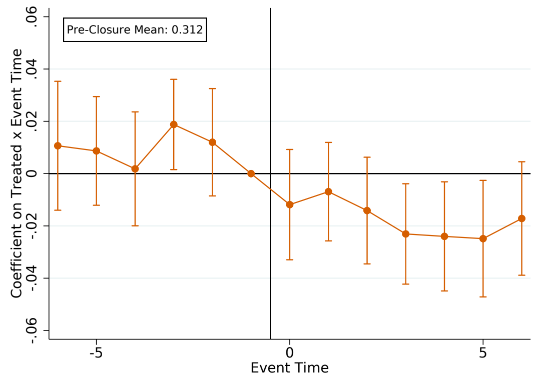
(f) High-Risk Cesarean Rate, Weighted By Births

Note: Panels (a) - (f) plot the Cesarean rates of closure counties and receiving counties in the years prior to closure. Panel (a) plots the average Cesarean rate of closure counties and receiving counties. Panel (c) plots the average low-risk Cesarean rate of closure counties and receiving counties and Panel (e) plots the average high-risk Cesarean rate of closure counties and receiving counties, where the cutoff for "low" vs. "high" risk is a predicted probability of a Cesarean of 0.30. Panels (b), (d) and (f) repeat Panels (a), (c) and (e), but weight by the number of births occurring in a county.

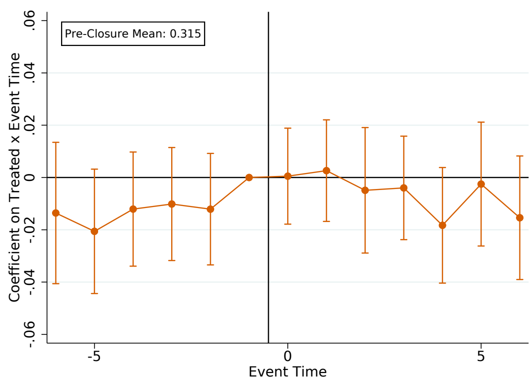
Figure 10: Impact of Closure on Cesarean Rates by Initial Differences in Sending and Receiving Counties



(a) Receiving County Cesarean Rate < Closing County Cesarean Rate



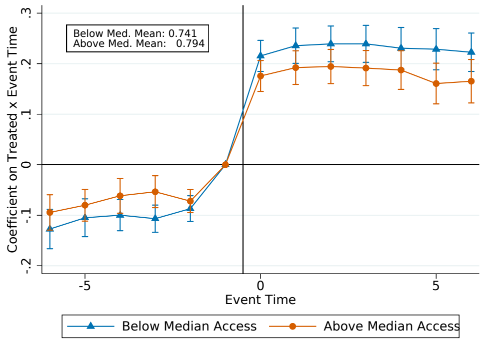
(b) Receiving County Cesarean Rate = Closing County Cesarean Rate



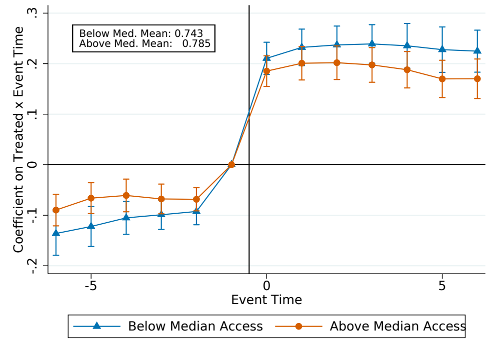
(c) Receiving County Cesarean Rate > Closing County Cesarean Rate

Note: In Panels (a) - (c), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (1). The dependent variable in all panels is the share of births delivered via Cesarean. Each panel is estimated on the sample of births where the receiving county has a lower rate of Cesarean birth (Panel (a)), roughly the same rate of Cesarean birth (Panel (b)), or a higher rate of Cesarean birth (Panel (c)). Observations are at the county-event time level and are clustered at the county level.

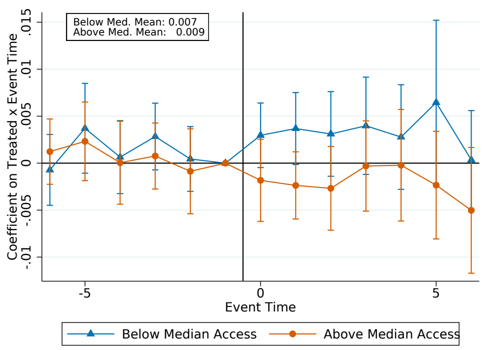
Figure 11: Estimated Impact of Closure on Selected Outcomes by Access to Alternatives



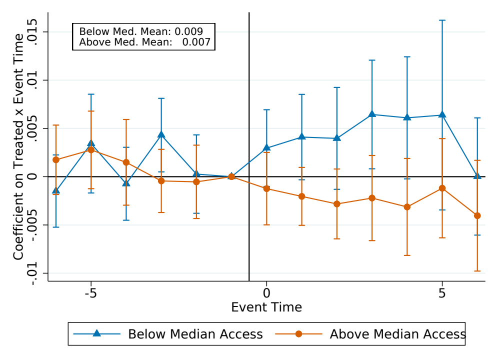
(a) Out-of-County Births, Number of Adjacent Options



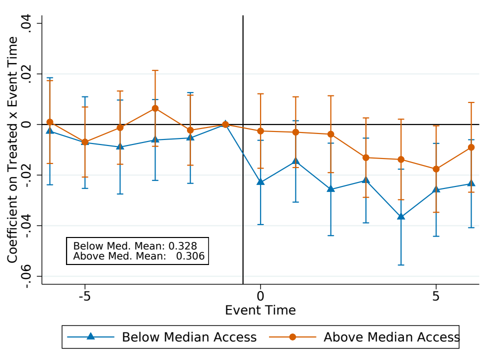
(b) Out-of-County Births, Distance to Alternative



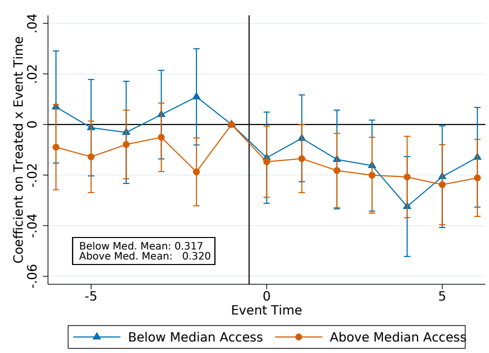
(c) Out-of-Hospital Births, Number of Adjacent Options



(d) Out-of-Hospital Births, Distance to Alternative



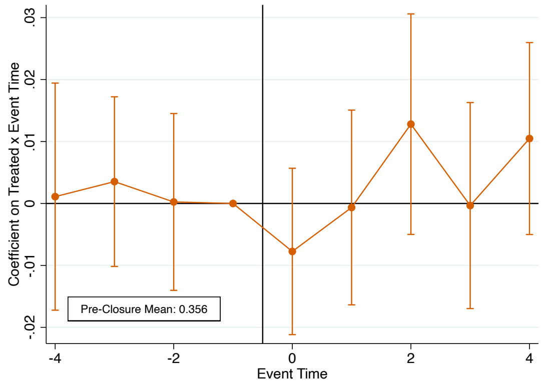
(e) Cesarean Rate, Number of Adjacent Options



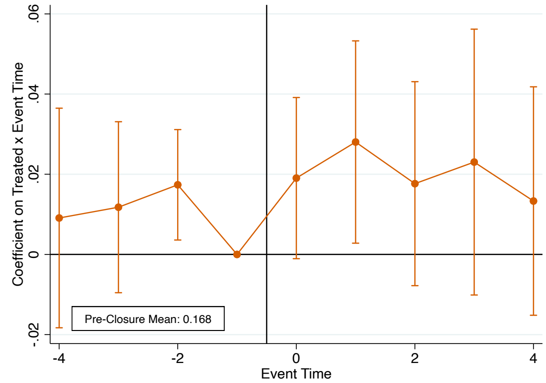
(f) Cesarean Rate, Distance to Alternative

Note: Each point represents the treat-control difference from estimating Equation (1) by above/below median access to alternatives. The dependent variable in Panels (a) - (b) is the share of births occurring out of county, in Panels (c) - (d) is the share of births occurring out of hospital, and in Panels (e) - (f) is the share of births delivered via Cesarean. For each dependent variables, the sample is split above/below median based on access to available alternatives, measured as the number of hospitals with maternity wards in adjacent counties (Panels (a), (c), and (e)) or as the distance to the nearest hospital with a maternity ward (Panels (b), (d), and (f)). Observations are at the county-event time level and are clustered at the county level.

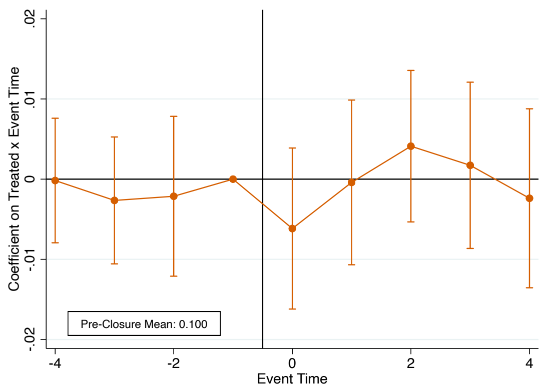
Figure 12: Estimated Impact of Closure on Maternal Outcomes, Texas Data



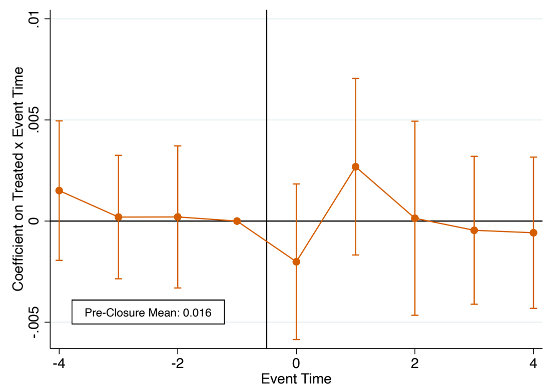
(a) Cesarean



(b) Induction



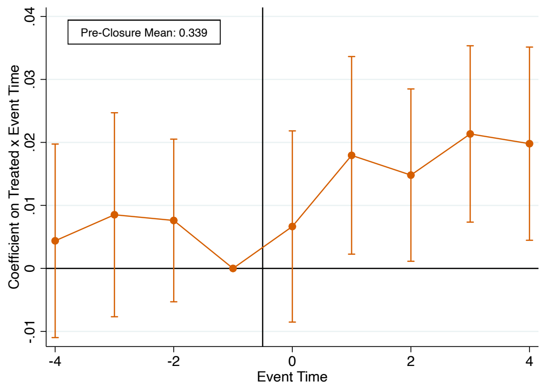
(c) Length of Stay > 3 Days



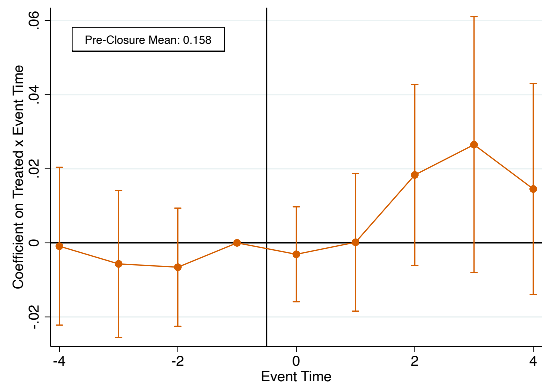
(d) Any Severe Maternal Morbidity

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (3). The dependent variable is an indicator for if a birth was delivered via Cesarean (Panel (a)), if the birth was induced (Panel (b)), if the length of stay was more than 3 days (Panel (c)), and if there were any severe maternal morbidities (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

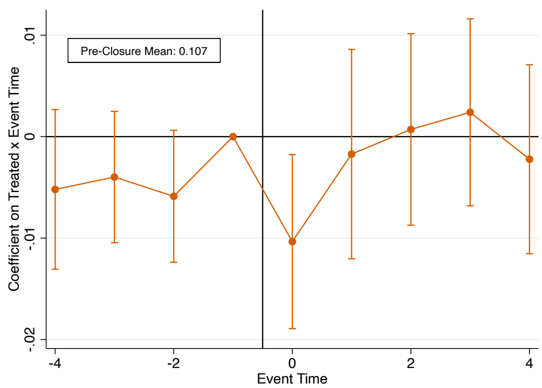
Figure 13: Estimated Impact of Closure on Maternal Outcomes in Receiving Hospitals, Texas Data



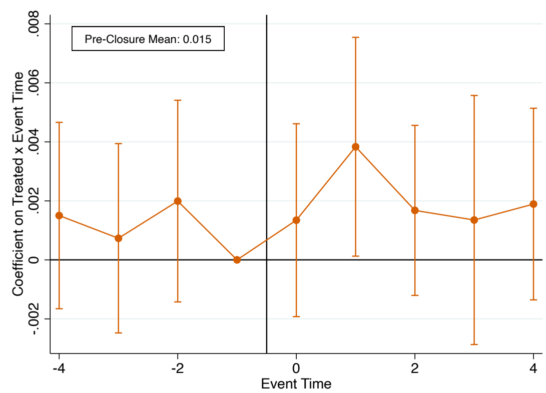
(a) Cesarean



(b) Induction



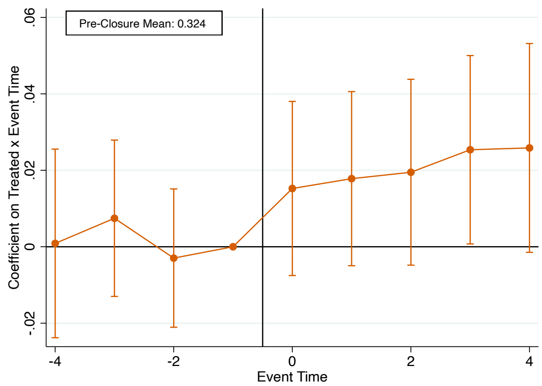
(c) Length of Stay > 3 Days



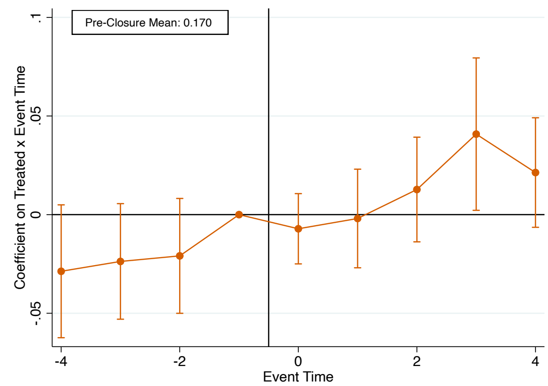
(d) Any Severe Maternal Morbidity

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (3). The dependent variable is an indicator for if a birth was delivered via Cesarean (Panel (a)), if the birth was induced (Panel (b)), if the length of stay was more than 3 days (Panel (c)), and if there were any severe maternal morbidities (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

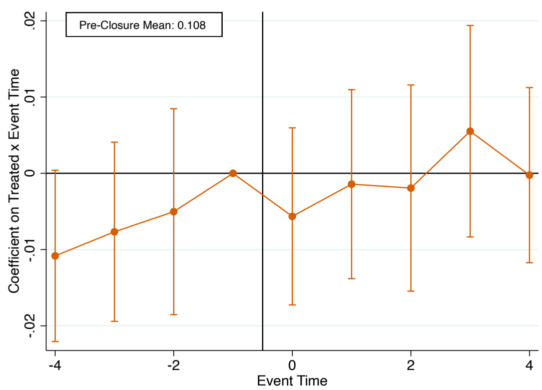
Figure 14: Estimated Impact of Closure on Maternal Outcomes in Receiving Hospitals, Above Median Exposure, Texas Data



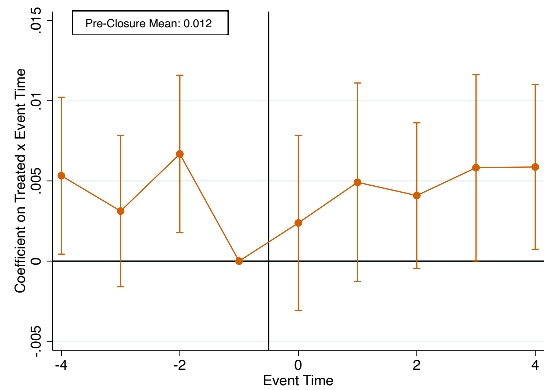
(a) Cesarean



(b) Induction



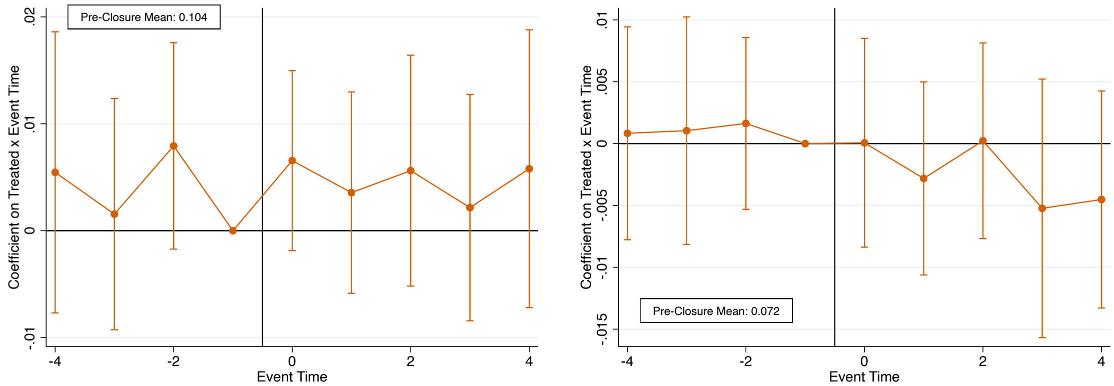
(c) Length of Stay > 3 Days



(d) Any Severe Maternal Morbidity

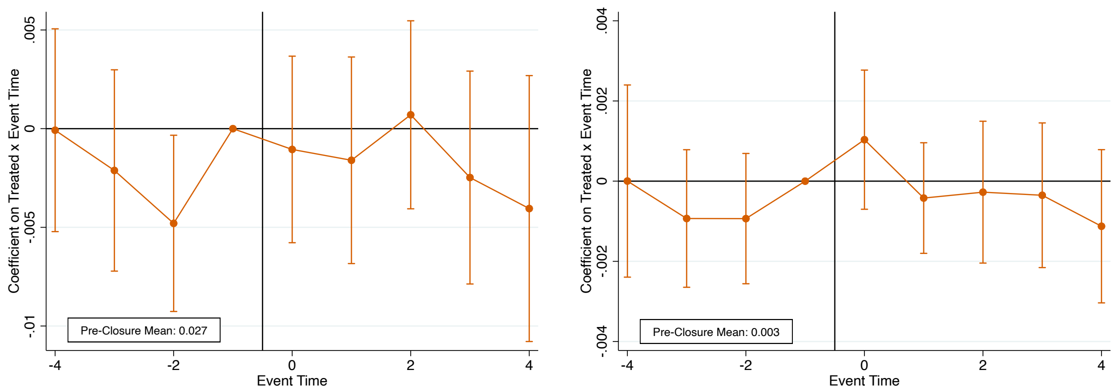
Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the β_τ coefficient from estimating Equation (3). The dependent variable is an indicator for if a birth was delivered via Cesarean (Panel (a)), if the birth was induced (Panel (b)), if the length of stay was more than 3 days (Panel (c)), and if there were any severe maternal morbidities (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

Figure 15: Estimated Impact of Closure on Infant Outcomes, Texas Data



(a) Length of Stay > 3 Days

(b) Preterm Birth

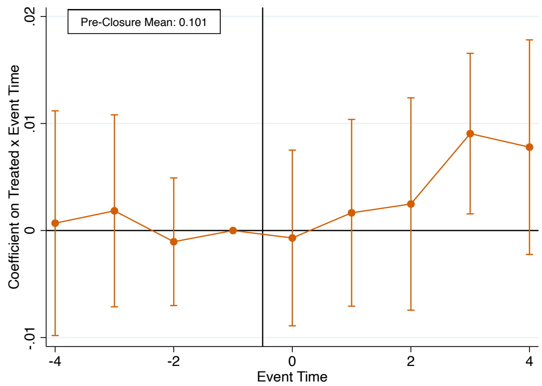


(c) Low Birth Weight

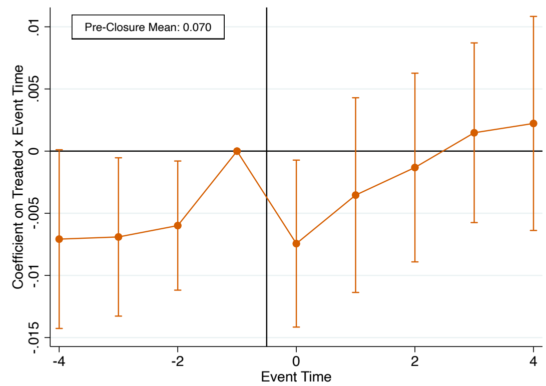
(d) Infant Mortality

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (3). The dependent variable is an indicator for if the length of stay was more than 3 days (Panel (a)), if the birth was preterm (Panel (b)), if birth was low birth weight (Panel (c)), and if the newborn died during the initial hospital stay (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

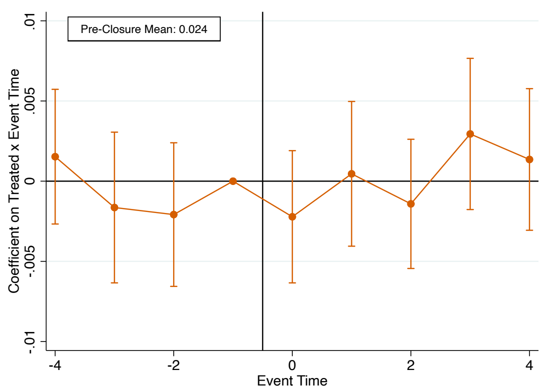
Figure 16: Estimated Impact of Closure on Infant Outcomes for Receiving Hospitals, Texas Data



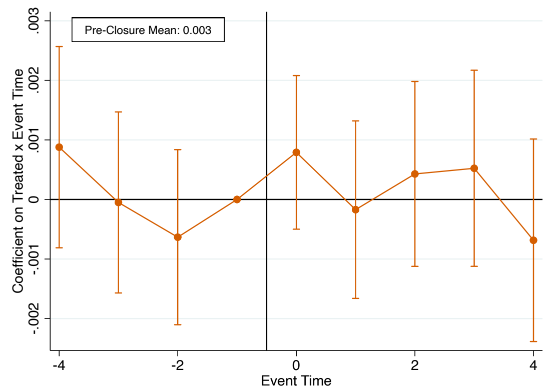
(a) Length of Stay > 3 Days



(b) Preterm Birth



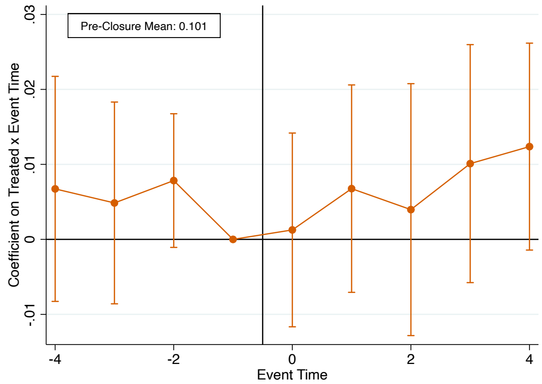
(c) Low Birth Weight



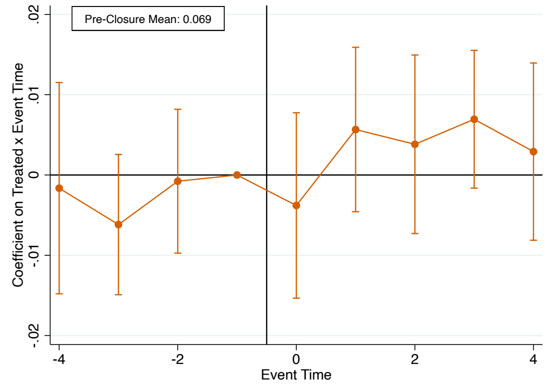
(d) Infant Mortality

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (3). The dependent variable is an indicator for if the length of stay was more than 3 days (Panel (a)), if the birth was preterm (Panel (b)), if birth was low birth weight (Panel (c)), and if the newborn died during the initial hospital stay (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

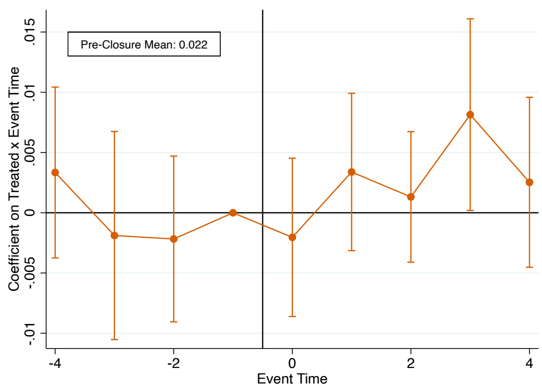
Figure 17: Estimated Impact of Closure on Infant Outcomes for Receiving Hospitals, Above Median Exposure, Texas Data



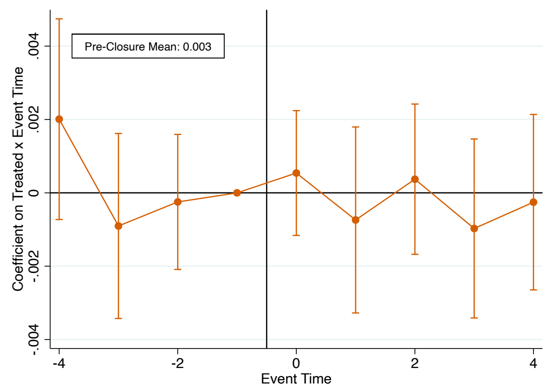
(a) Length of Stay > 3 Days



(b) Preterm Birth



(c) Low Birth Weight



(d) Infant Mortality

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating Equation (3). The dependent variable is an indicator for if the length of stay was more than 3 days (Panel (a)), if the birth was preterm (Panel (b)), if birth was low birth weight (Panel (c)), and if the newborn died during the initial hospital stay (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

Table 1: Summary Statistics, Full US

	(1) Closure	(2) Never Open	(3) Always Open
Population	21,946	14,757	151,207
% Female 18-44	20.0	19.7	21.7
% Black	10.0	9.3	8.1
% College	18.6	18.7	25.7
Unemployment Rate	6.2	6.2	5.7
Number of Establishments	477	308	4089
Per Capita Income	16,122	16,266	18,739
Per Capita Transfers	3,671	3,491	3,300
N	391	1,150	1,591

Note: This table displays summary statistics for counties that experience a maternity ward closure between 1996 and 2018 (Column 1)), counties that are always open between 1996 and 2018 (Column 2), and counties that are never open between 1996 and 2018 (Column 3).

Table 2: Summary Statistics, Texas

	(1) At Least 1 Change	(2) No Change
Population	130,060	30,930
% Female 18-44	20.1	19.7
% Black	8.6	5.3
% College	18.8	20.2
Unemployment Rate	6.5	5.9
Number of Establishments	3,075	660
Per Capita Income	17,593	17,739
Per Capita Transfers	3,564	3,385
N	112	142

Note: This table displays summary statistics for counties in Texas that have at least one zip code that experiences a maternity ward closure between 2000 and 2014 (Column 1) and counties that do not have any zip code that experiences a maternity ward closure from 2000 to 2014 (Column 2).

Table 3: Estimated Effects of Closure

	β_0	β_5	$\overline{\beta}_\tau$
	(1)	(2)	(3)
Panel A: First Stage			
Number of Births	-78.600***	-78.713***	-82.826***
	(7.202)	(10.883)	(8.947)
	[89.805]	[89.805]	[89.805]
Share Out-of-County Births	0.198***	0.199***	0.208***
	(0.011)	(0.015)	(0.012)
	[0.764]	[0.764]	[0.764]
Panel B: Characteristics of Pregnancy and Birth			
Share Out-of-Hospital Births	0.001	0.003	0.001
	(0.001)	(0.003)	(0.001)
	[0.008]	[0.008]	[0.008]
Share With No Prenatal Visits	0.000	0.001	0.001
	(0.001)	(0.001)	(0.001)
	[0.009]	[0.009]	[0.009]
Share Induced	0.005	-0.009	-0.001
	(0.006)	(0.010)	(0.007)
	[0.282]	[0.282]	[0.282]
Share C-Section	-0.014**	-0.022***	-0.018***
	(0.006)	(0.006)	(0.005)
	[0.318]	[0.318]	[0.318]
Panel C: Infant Health			
Share Low Birth Weight	-0.004	-0.001	-0.003
	(0.003)	(0.003)	(0.003)
	[0.085]	[0.085]	[0.085]
Share Apgar Score ≤ 6	-0.002	-0.0002	-0.001
	(0.002)	(0.003)	(0.002)
	[0.020]	[0.020]	[0.020]
Share Preterm	-0.007	-0.007*	-0.004
	(0.004)	(0.004)	(0.003)
	[0.133]	[0.133]	[0.133]
Infant Mortality Rate	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
	[0.007]	[0.007]	[0.007]
Observations	8,970	8,970	8,970
Clusters	390	390	390

Note: This table presents results from estimating Equation (1). Each row represents a separate regression with the dependent variable specified in the row. The estimated effects in Columns 1, 2, and 3 correspond to β_0, β_5, and the post-period average of the β_τ coefficients. The treatment group's average of the dependent variable in event time $\tau = -1$ is displayed in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, = p-value < 0.05, = p-value < 0.1.

Table 4: Estimated Effect of Closure on Cesarean Rates by Pregnancy Risk

	β_0 (1)	β_5 (2)	$\overline{\beta}_\tau$ (3)
Panel A: Low-Risk			
Estimated Effect [0.164]	-0.012*	-0.015*	-0.016**
	(0.007)	(0.009)	(0.007)
Observations	8,919	8,919	8,919
Clusters	390	390	390
Panel B: High-Risk			
Estimated Effect [0.773]	0.006	0.008	0.013
	(0.014)	(0.013)	(0.009)
Observations	8,892	8,892	8,892
Clusters	390	390	390
County FE	Yes	Yes	Yes
Event Time FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Note: This table presents results from estimating Equation (1) with the dependent variable being the rate of Cesarean births in a county. Panel A estimates (1) for low-risk women (Predicted Probability of Cesarean ≤ 0.30) and Panel B estimates (1) for high-risk women (PPC > 0.30). The estimated effects in Columns 1, 2, and 3 correspond to β_0, β_5, and the post-period average of the β_τ coefficients, respectively. The treatment group's average Cesarean rate in event time $\tau = -1$ is displayed in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, $=$ p-value < 0.05, $=$ p-value < 0.1.

Table 5: Estimated Effect of Closure on Cesarean Rates by Differences in Closure and Receiving County

	β_0 (1)	β_5 (2)	$\overline{\beta}_\tau$ (3)
Panel A: Receiving County Has Lower C-Section Rate			
Estimated Effect	-0.033***	-0.036***	-0.030***
	(0.009)	(0.010)	(0.008)
	[0.329]	[0.329]	[0.329]
Observations	2,990	2,990	2,990
Clusters	130	130	130
Panel B: Receiving County Has Same C-Section Rate			
Estimated Effect	-0.012	-0.025**	-0.017**
	(0.011)	(0.011)	(0.008)
	[0.312]	[0.312]	[0.312]
Observations	2,987	2,987	2,987
Clusters	130	130	130
Panel C: Receiving County Has Higher C-Section Rate			
Estimated Effect	0.001	-0.003	-0.006
	(0.009)	(0.012)	(0.009)
	[0.315]	[0.315]	[0.315]
Observations	2,944	2,944	2,944
Clusters	128	128	128

Note: This table presents results from estimating Equation (1) with the dependent variable being the rate of Cesarean births in a county. Each row represents a separate regression of Equation (1) based on initial differences in Cesarean rates between closure and receiving counties. The estimated effects in Columns 1, 2, and 3 correspond to β_0, β_5, and the post-period average of the β_τ coefficients, respectively. The treatment group's average Cesarean rate in event time $\tau = -1$ is displayed in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, = p-value < 0.05, = p-value < 0.1.

Table 6: Estimated Effects of Closure on Women By Alternatives in Adjacent County

	Above Median Access			Below Median Access		
	β_0	β_5	$\overline{\beta}_\tau$	β_0	β_5	$\overline{\beta}_\tau$
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: First Stage						
Number of Births	-81.430***	-64.093***	-77.739***	-76.367***	-90.248***	-86.840***
	(10.917)	(13.719)	(12.187)	(9.630)	(16.139)	(12.810)
	[91.884]	[91.884]	[91.884]	[88.165]	[88.165]	[88.165]
Share Out-of-County Births	0.176***	0.161***	0.181***	0.215***	0.229***	0.230***
	(0.015)	(0.020)	(0.017)	(0.016)	(0.021)	(0.017)
	[0.794]	[0.794]	[0.794]	[0.741]	[0.741]	[0.741]
Panel B: Characteristics of Pregnancy and Birth						
Share Out-of-Hospital Births	-0.002	-0.002	-0.002	0.003*	0.006	0.003
	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)	(0.002)
	[0.009]	[0.009]	[0.009]	[0.007]	[0.007]	[0.007]
Share With One or Fewer Prenatal Visits	-0.001	-0.001	0.001	0.001	0.003	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
	[0.009]	[0.009]	[0.009]	[0.008]	[0.008]	[0.008]
Share Induced	0.005	-0.006	-0.005	0.004	-0.012	0.003
	(0.009)	(0.015)	(0.010)	(0.009)	(0.012)	(0.008)
	[0.277]	[0.277]	[0.277]	[0.286]	[0.286]	[0.286]
Share C-Section	-0.003	-0.018**	-0.009	-0.023***	-0.026***	-0.024***
	(0.007)	(0.009)	(0.006)	(0.008)	(0.009)	(0.007)
	[0.306]	[0.306]	[0.306]	[0.328]	[0.328]	[0.328]
Panel C: Infant Health						
Share Low Birth Weight	-0.005	-0.004	-0.006*	-0.002	0.002	-0.000
	(0.004)	(0.005)	(0.003)	(0.005)	(0.005)	(0.004)
	[0.083]	[0.083]	[0.083]	[0.086]	[0.086]	[0.086]
Share Apgar Score ≤ 6	-0.001	0.001	-0.000	-0.003	-0.001	-0.002
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
	[0.019]	[0.019]	[0.019]	[0.021]	[0.021]	[0.021]
Share Preterm	-0.002	-0.005	-0.002	-0.010	-0.008	-0.006
	(0.005)	(0.005)	(0.004)	(0.007)	(0.006)	(0.005)
	[0.126]	[0.126]	[0.126]	[0.139]	[0.139]	[0.139]
Infant Mortality Rate	-0.001	-0.000	0.000	0.003	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
	[0.006]	[0.006]	[0.006]	[0.007]	[0.007]	[0.007]
Observations	3,956	3,956	3,956	5,014	5,014	5,014
Clusters	172	172	172	218	218	218

Note: This table presents results from estimating Equation (1) for women based on their access to alternatives in adjacent county. Each row represents a separate regression of Equation (1) with the dependent variable specified in the row. The sample in columns 1-3 are counties with above-median access and in columns 4-6 are counties with below-median access. The estimated effects in Columns 1/4, 2/5, and 3/6 correspond to β_0, β_5, and the post-period average of the β_τ coefficients, respectively. The treatment group's average of the dependent variable in event time $\tau = -1$ is displayed in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, = p-value < 0.05, = p-value < 0.1.

Table 7: Estimated Effects of Closure on Women By Travel Distance to Nearest Maternity Ward

	Above Median Access			Below Median Access		
	β_0	β_5	$\overline{\beta}_\tau$	β_0	β_5	$\overline{\beta}_\tau$
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: First Stage						
Number of Births	-98.500***	-83.020***	-94.714***	-58.495***	-74.361***	-70.816***
	(12.286)	(15.227)	(13.760)	(6.680)	(15.027)	(10.764)
	[112.561]	[112.561]	[112.561]	[66.814]	[66.814]	[66.814]
Share Out-of-County Births	0.185***	0.170***	0.188***	0.211***	0.228***	0.230***
	(0.015)	(0.019)	(0.017)	(0.016)	(0.023)	(0.019)
	[0.785]	[0.785]	[0.785]	[0.743]	[0.743]	[0.743]
Panel B: Characteristics of Pregnancy and Birth						
Share Out-of-Hospital Births	-0.001	-0.001	-0.002	0.003	0.006	0.004*
	(0.002)	(0.003)	(0.002)	(0.002)	(0.005)	(0.002)
	[0.007]	[0.007]	[0.007]	[0.009]	[0.009]	[0.009]
Share With One or Fewer Prenatal Visits	0.001	0.002	0.002	-0.000	0.001	0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
	[0.008]	[0.008]	[0.008]	[0.009]	[0.009]	[0.009]
Share Induced	0.009	-0.000	0.006	0.001	-0.019	-0.008
	(0.008)	(0.013)	(0.010)	(0.010)	(0.014)	(0.009)
	[0.276]	[0.276]	[0.276]	[0.289]	[0.289]	[0.289]
Share C-Section	-0.015**	-0.024***	-0.019***	-0.013	-0.021**	-0.016**
	(0.007)	(0.008)	(0.006)	(0.009)	(0.010)	(0.007)
	[0.320]	[0.320]	[0.320]	[0.317]	[0.317]	[0.317]
Panel C: Infant Health						
Share Low Birth Weight	-0.001	-0.003	-0.004	-0.006	0.001	-0.001
	(0.004)	(0.004)	(0.003)	(0.006)	(0.005)	(0.004)
	[0.087]	[0.087]	[0.087]	[0.083]	[0.083]	[0.083]
Share Apgar Score ≤ 6	-0.001	-0.003	-0.002	-0.004	0.004	-0.000
	(0.002)	(0.003)	(0.002)	(0.004)	(0.004)	(0.003)
	[0.017]	[0.017]	[0.017]	[0.023]	[0.023]	[0.023]
Share Preterm	-0.002	-0.008	-0.007**	-0.011*	-0.005	-0.001
	(0.005)	(0.005)	(0.004)	(0.007)	(0.006)	(0.005)
	[0.138]	[0.138]	[0.138]	[0.129]	[0.129]	[0.129]
Infant Mortality Rate	0.001	-0.000	-0.000	0.001	0.002	0.003
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Observations	4,508	4,508	4,508	4,462	4,462	4,462
Clusters	196	196	196	194	194	194

Note: This table presents results from estimating Equation (1) for women based on their travel distance to the closest maternity ward following closure. Each row represents a separate regression of Equation (1) with the dependent variable specified in the row. The sample in columns 1-3 are counties with above-median access and in columns 4-6 are counties with below-median access. The estimated effects in Columns 1/4, 2/5, and 3/6 correspond to β_0, β_5, and the post-period average of the β_τ coefficients, respectively. The treatment group's average of the dependent variable in event time $\tau = -1$ is displayed in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, = p-value < 0.05, = p-value < 0.1.

Table 8: Estimated Effects of Closure on Women in Receiving Counties

	β_0 (1)	β_5 (2)	$\overline{\beta}_\tau$ (3)
Panel A: First Stage			
Number of Births [1,291.546]	20.011	14.115	19.879
	(16.254)	(38.210)	(26.658)
Share Out-of-County Births [0.294]	0.002	0.007	0.002
	(0.007)	(0.010)	(0.007)
Panel B: Characteristics of Pregnancy and Birth			
Share Out-of-Hospital Births [0.010]	-0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)
Share With One or Fewer Prenatal Visits [0.009]	0.001	-0.000	0.000
	(0.001)	(0.002)	(0.001)
Share Induced [0.285]	0.005	-0.002	-0.001
	(0.006)	(0.009)	(0.007)
Share C-Section [0.308]	-0.010**	-0.004	-0.007**
	(0.004)	(0.005)	(0.004)
Panel C: Infant Health			
Share Low Birth Weight [0.082]	-0.003	-0.002	-0.002
	(0.002)	(0.003)	(0.002)
Share Apgar Score ≤ 6 [0.015]	-0.003	-0.005	-0.004
	(0.002)	(0.002)	(0.002)
Share Preterm [0.129]	-0.003	0.000	-0.001
	(0.003)	(0.003)	(0.002)
Infant Mortality Rate [0.007]	-0.001	-0.002**	-0.000
	(0.001)	(0.001)	(0.001)
Observations	8,418	8,418	8,418
Clusters	366	366	366
County FE	Yes	Yes	Yes
Event Time FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Note: This table presents results from estimating Equation (1) for women residing in receiving counties as described in the text. Each row represents a separate regression of Equation (1) with the dependent variable specified in the row. The estimated effects in Columns 1, 2, and 3 correspond to β_0, β_5, and the post-period average of the β_τ coefficients, respectively. The treatment group's average of the dependent variable in event time $\tau = -1$ is displayed next to the dependent variable in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, = p-value < 0.05, = p-value < 0.1.

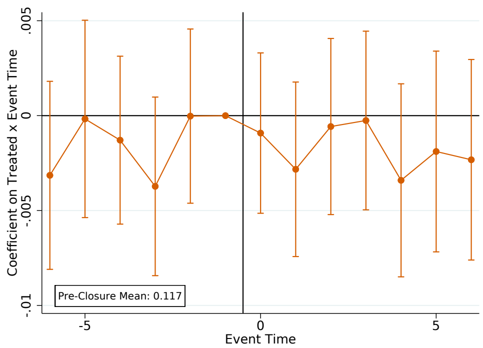
Table 9: Estimated Effects of Closure on Women By Demographic Subgroup

	US-Born Black (1)	US-Born Hispanic (2)	High School & Below (3)	College & Above (4)	Less Than 20 Years (5)	More Than 35 Years (6)
Panel A: First Stage						
Number of Births	-12.760**	-4.632**	-25.380***	-6.143***	-7.712***	-4.126***
	(5.826)	(2.045)	(4.881)	(1.452)	(2.283)	(0.843)
	[23.739]	[3.810]	[42.263]	[5.476]	[16.788]	[5.031]
Share Out-of-County Births	0.139***	0.194***	0.193***	0.075***	0.191***	0.126***
	(0.028)	(0.037)	(0.016)	(0.013)	(0.017)	(0.017)
	[0.802]	[0.788]	[0.776]	[0.896]	[0.780]	[0.834]
Panel B: Characteristics of Pregnancy and Birth						
Share Out-of-Hospital Births	-0.001	0.011	-0.001	0.004	0.001	0.003
	(0.002)	(0.007)	(0.003)	(0.003)	(0.003)	(0.006)
	[0.002]	[0.003]	[0.009]	[0.008]	[0.004]	[0.022]
Share With One or Fewer Prenatal Visits	-0.002	0.001	0.002	0.000	0.003	0.000
	(0.009)	(0.005)	(0.002)	(0.001)	(0.003)	(0.004)
	[0.020]	[0.010]	[0.013]	[0.002]	[0.012]	[0.015]
Share Induced	-0.005	0.032	0.008	-0.001	-0.005	0.018
	(0.022)	(0.033)	(0.010)	(0.012)	(0.013)	(0.015)
	[0.225]	[0.225]	[0.277]	[0.308]	[0.311]	[0.248]
Share Cesarean	-0.027	-0.062*	-0.014**	-0.018	-0.012	0.003
	(0.024)	(0.032)	(0.007)	(0.012)	(0.010)	(0.015)
	[0.347]	[0.338]	[0.307]	[0.350]	[0.246]	[0.411]
Panel C: Infant Health						
Share Low Birth Weight	-0.007	-0.012	-0.003	-0.011	0.010	-0.002
	(0.021)	(0.018)	(0.005)	(0.007)	(0.007)	(0.009)
	[0.150]	[0.085]	[0.092]	[0.069]	[0.091]	[0.104]
Share Preterm	-0.009	-0.011	-0.002	0.000	0.010	-0.002
	(0.027)	(0.023)	(0.006)	(0.009)	(0.008)	(0.012)
	[0.193]	[0.140]	[0.137]	[0.117]	[0.142]	[0.169]
Infant Mortality Rate	0.001	-0.006	0.001	0.001	0.001	0.005*
	(0.006)	(0.006)	(0.001)	(0.001)	(0.002)	(0.003)
	[0.011]	[0.014]	[0.007]	[0.003]	[0.008]	[0.005]
Observations	3,161	2,900	8,045	7,728	8,692	8,779
Clusters	138	127	350	336	378	382

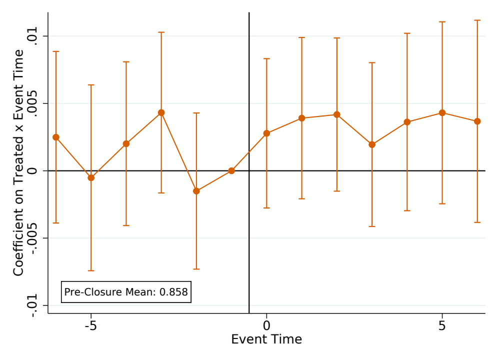
Note: This table presents results from estimating Equation (1) for women based on their demographic subgroup. Each coefficient represents the β_τ coefficient from a separate regression with the dependent variable specified in the row and the sample specified in the column. The treatment group's average of the dependent variable in event time $\tau = -1$ is displayed in brackets. Standard errors are clustered at the county level. Stars report statistical significance: *** = p-value < 0.01, = p-value < 0.05, = p-value < 0.1.

Appendix A Additional Results

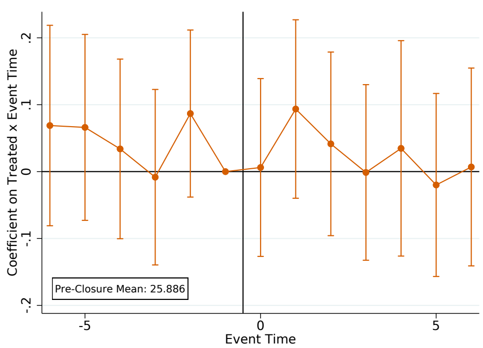
Figure A1: Estimated Impact of Closure on Composition



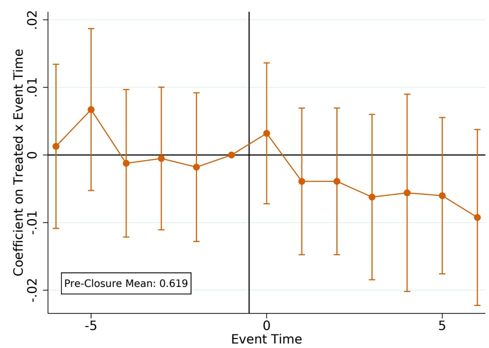
(a) Share Black



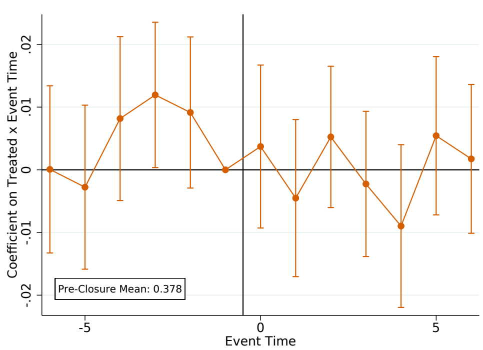
(b) Share White



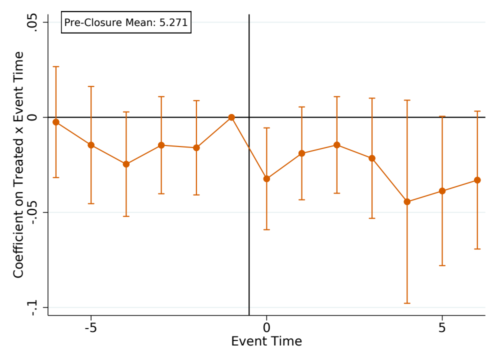
(c) Age



(d) Share Married



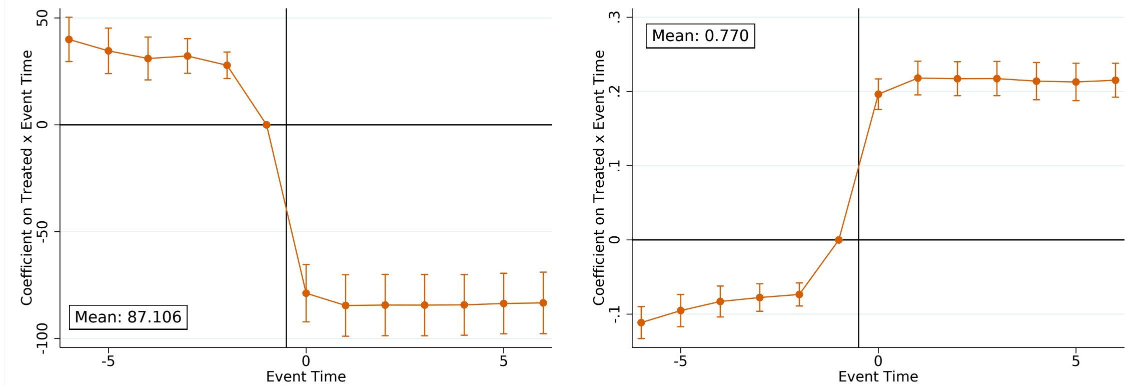
(e) Share First Birth



(f) Log of Births to Residents

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births to Black women (Panel (a)), the share of births to white women (Panel (b)), age at birth (Panel (c)), the share of births to married women (Panel (d)), the share of first births (Panel (e)), and the log of births to residents of a county (Panel (f)). Observations are at the county-event time level and are clustered at the county level.

Figure A2: Estimated Impact of Closure on County Births, Control Never Provided Maternity Care

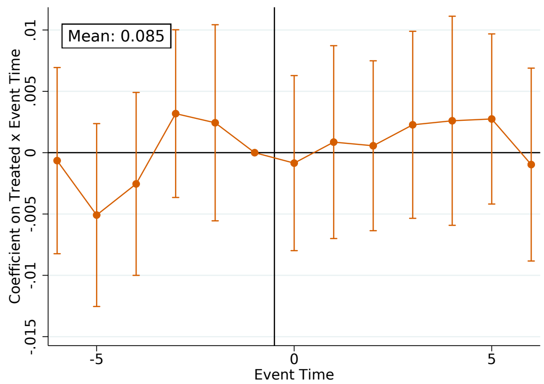


(a) Number of Births in County

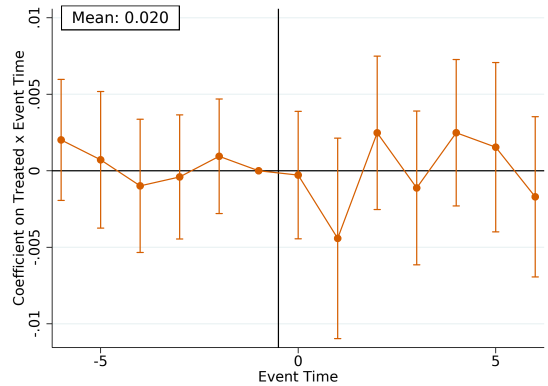
(b) Resident Births Occurring Out of County

Note: In Panels (a) and (b), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the number of births occurring within a county at event time τ and in Panel (b) is the share of births occurring to residents of a county occurring outside of the residence county. Observations are at the county-event time level and are clustered at the county level. The control counties are selected from counties that never provided maternity services from 1996 to 2018.

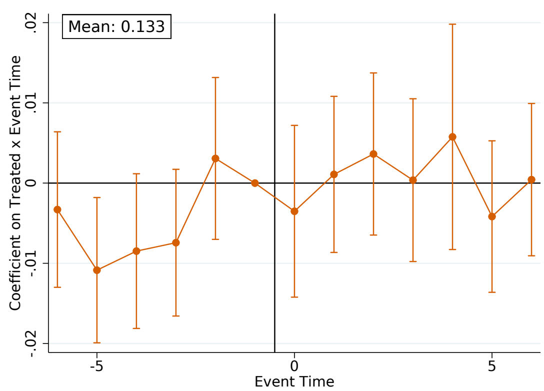
Figure A3: Estimated Impact of Closure on Infant Health, Control Never Provided Maternity Care



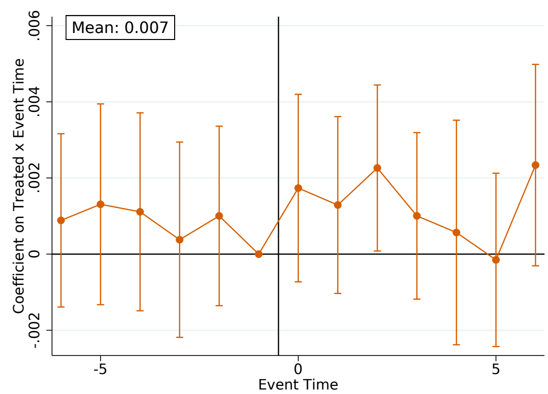
(a) Share of Births Low Birth Weight



(b) Share of Births With Apgar ≤ 6



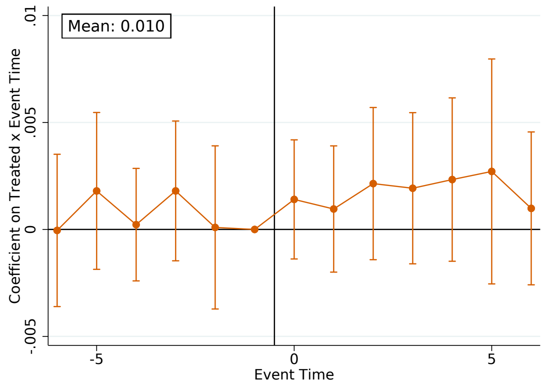
(c) Share of Births Preterm



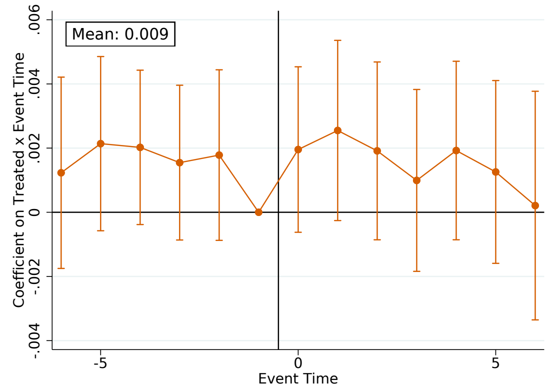
(d) Infant Mortality Rate

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births low birth weight (< 2500 grams), in Panel (b) is the share of births with an Apgar score less than or equal to 6, in Panel (c) is the share of births preterm (< 37 weeks gestation), and in Panel (d) is the infant mortality rate. Observations are at the county-event time level and are clustered at the county level. The control counties are selected from counties that never provided maternity services from 1996 to 2018.

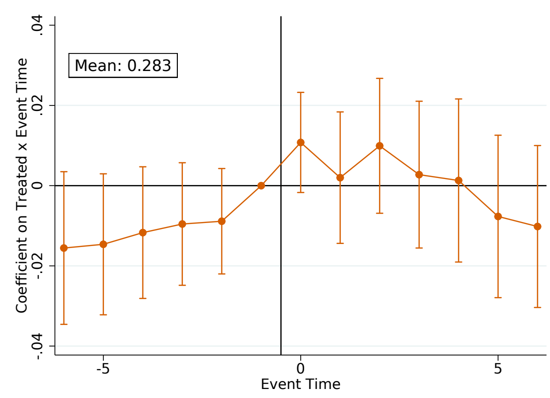
Figure A4: Estimated Impact of Closure on Characteristics of Pregnancy and Birth, Control Never Provided Maternity Care



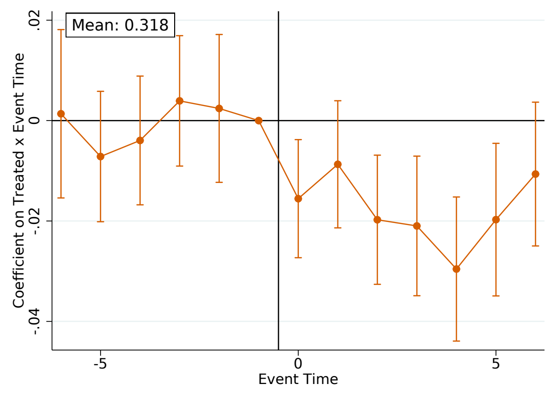
(a) Share of Births Out of Hospital



(b) Share of Pregnancies with 1 or Fewer Prenatal Visits



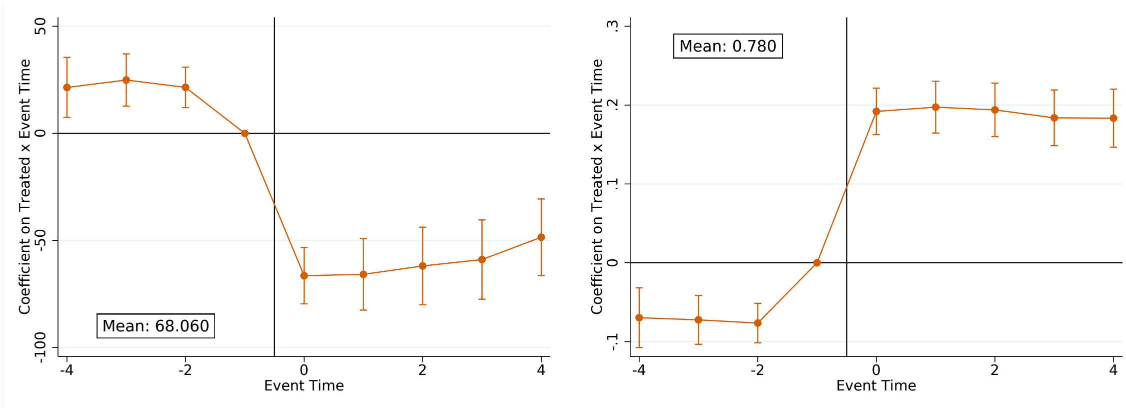
(c) Share of Births Induced



(d) Share of Births Delivered Via Cesarean

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births occurring outside of a hospital, in Panel (b) is the share of pregnancies with one or fewer prenatal visits, in Panel (c) is the share of births induced, and in Panel (d) is the share of deliveries that occur via a Cesarean. Observations are at the county-event time level and are clustered at the county level. The control counties are selected from counties that never provided maternity services from 1996 to 2018.

Figure A5: Estimated Impact of Closure on County Births, Control Closes Later

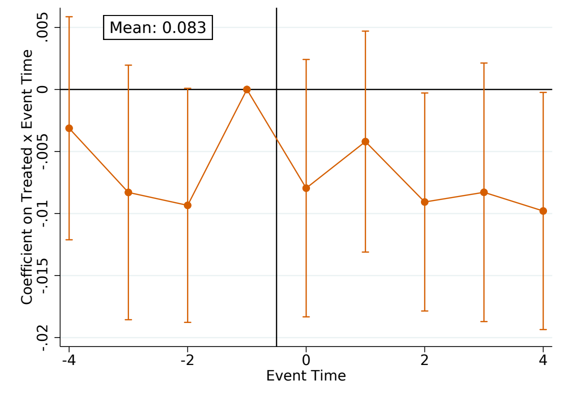


(a) Number of Births in County

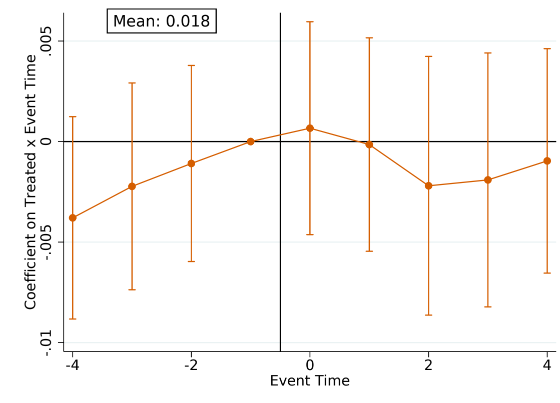
(b) Resident Births Occurring Out of County

Note: In Panels (a) and (b), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the number of births occurring within a county at event time τ and in Panel (b) is the share of births occurring to residents of a county occurring outside of the residence county. Observations are at the county-event time level and are clustered at the county level. The control counties are selected from counties that close within a state at least four years later.

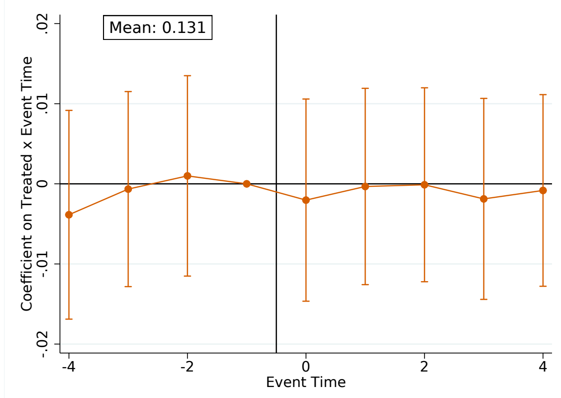
Figure A6: Estimated Impact of Closure on Infant Health, Control Closes Later



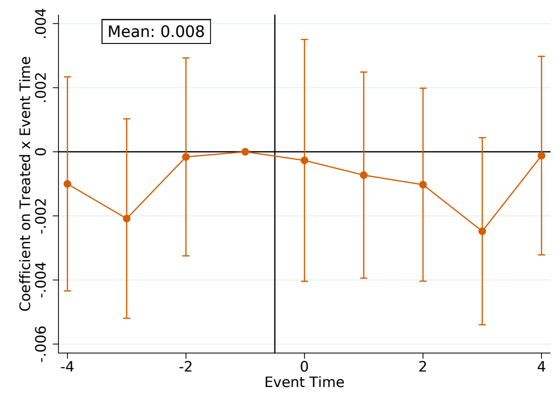
(a) Share of Births Low Birth Weight



(b) Share of Births With Apgar ≤ 6



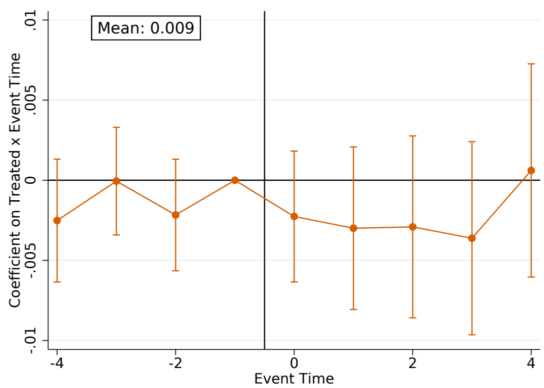
(c) Share of Births Preterm



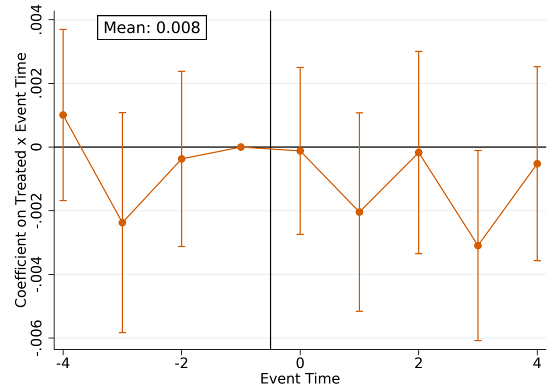
(d) Infant Mortality Rate

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births low birth weight (< 2500 grams), in Panel (b) is the share of births with an Apgar score less than or equal to 6, in Panel (c) is the share of births preterm (< 37 weeks gestation), and in Panel (d) is the infant mortality rate. Observations are at the county-event time level and are clustered at the county level. The control counties are selected from counties that close within a state at least four years later.

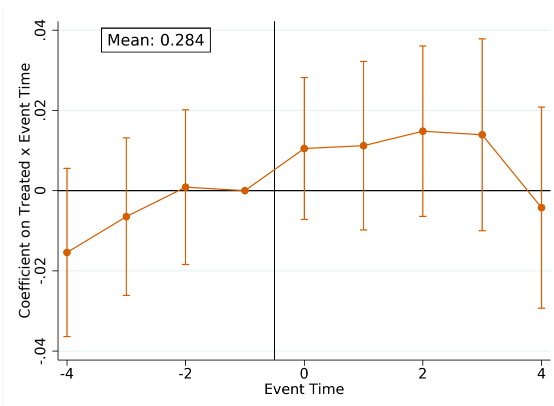
Figure A7: Estimated Impact of Closure on Characteristics of Pregnancy and Birth, Control Closes Later



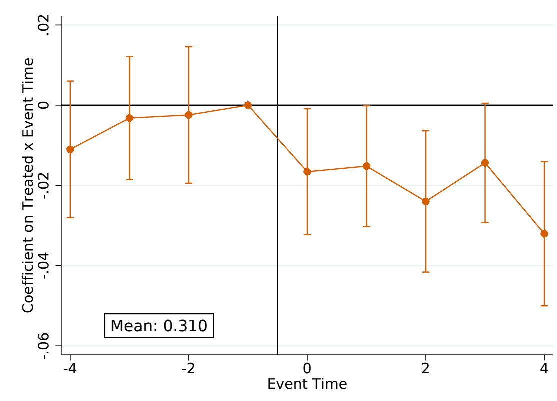
(a) Share of Births Out of Hospital



(b) Share of Pregnancies with 1 or Fewer Prenatal Visits



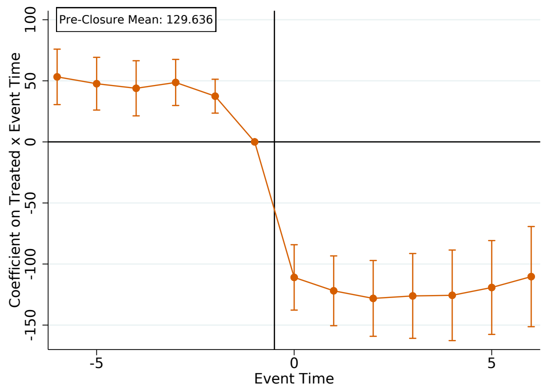
(c) Share of Births Induced



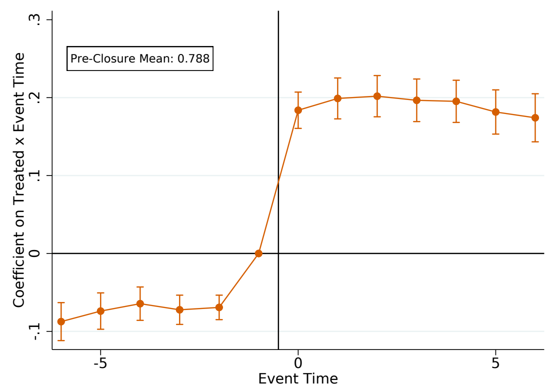
(d) Share of Births Delivered Via Cesarean

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births occurring outside of a hospital, in Panel (b) is the share of pregnancies with one or fewer prenatal visits, in Panel (c) is the share of births induced, and in Panel (d) is the share of deliveries that occur via a Cesarean. Observations are at the county-event time level and are clustered at the county level. The control counties are selected from counties that close within a state at least four years later.

Figure A8: Estimated Impact of Closure on County Births, Weighted



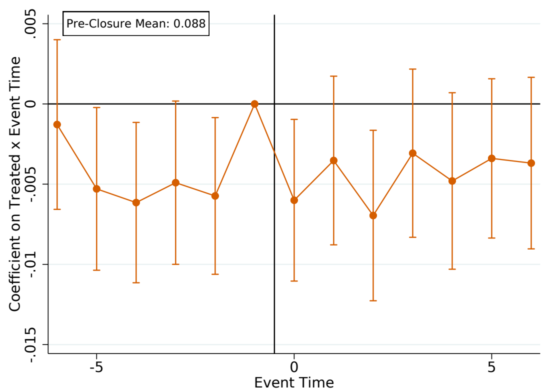
(a) Number of Births in County



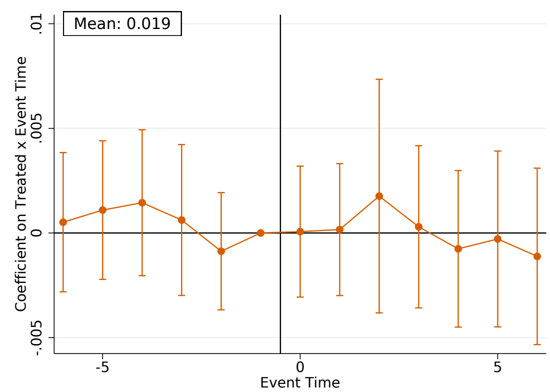
(b) Resident Births Occurring Out of County

Note: In Panels (a) and (b), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the number of births occurring within a county at event time τ and in Panel (b) is the share of births occurring to residents of a county occurring outside of the residence county. Observations at the county-event time level are weighted by the number of births to residents of a county and are clustered at the county level.

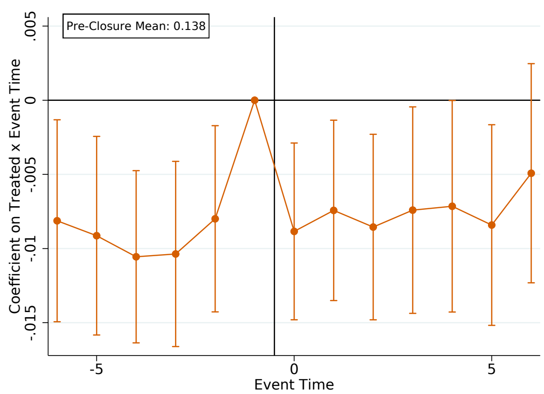
Figure A9: Estimated Impact of Closure on Infant Health, Weighted



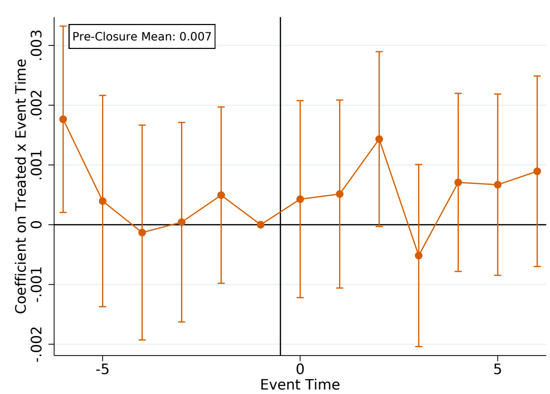
(a) Share of Births Low Birth Weight



(b) Share of Births With Apgar ≤ 6



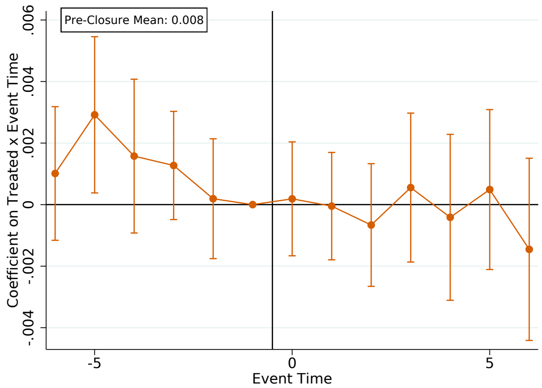
(c) Share of Births Preterm



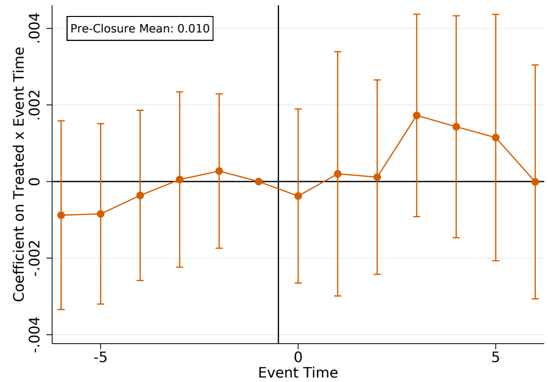
(d) Infant Mortality Rate

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births low birth weight (< 2500 grams), in Panel (b) is the share of births born with an Apgar score of 6 or below, in Panel (c) is the share of births preterm (< 37 weeks gestation), and in Panel (d) is the infant mortality rate. Observations at the county-event time level are weighted by the number of births to residents of a county and are clustered at the county level.

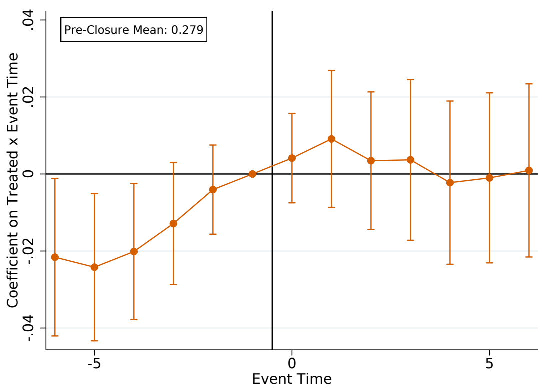
Figure A10: Estimated Impact of Closure on Characteristics of Pregnancy and Birth, Weighted



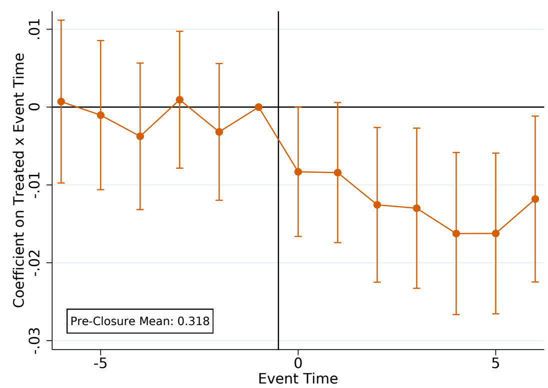
(a) Share of Births Out of Hospital



(b) Share of Pregnancies with 1 or Fewer Prenatal Visits



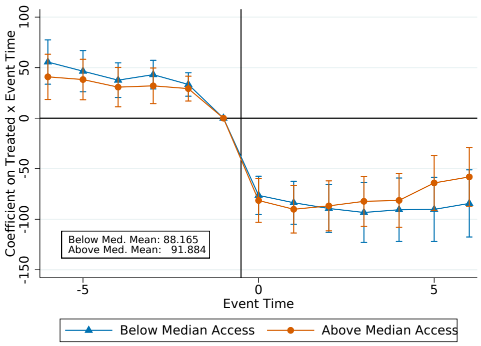
(c) Share of Births Induced



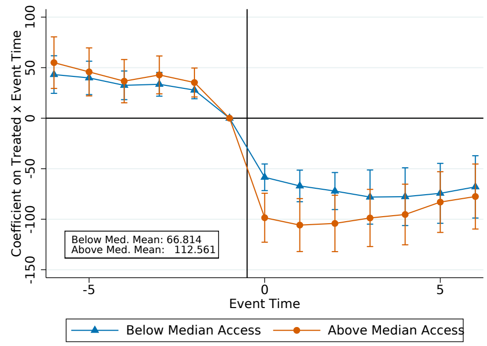
(d) Share of Births Delivered Via Cesarean

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births occurring outside of a hospital, in Panel (b) is the share of pregnancies with one or fewer prenatal visits, in Panel (c) is the share of births induced, and in Panel (d) is the share of deliveries that occur via a Cesarean. Observations at the county-event time level are weighted by the number of births to residents of a county and are clustered at the county level.

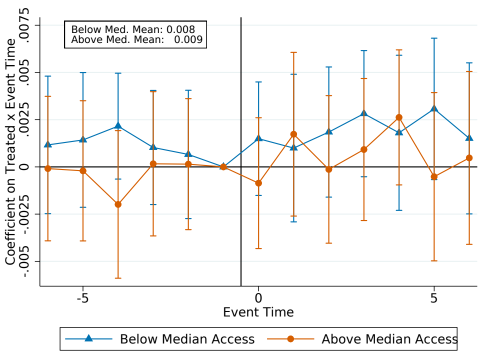
Figure A11: Estimated Impact of Closure by Access to Alternatives



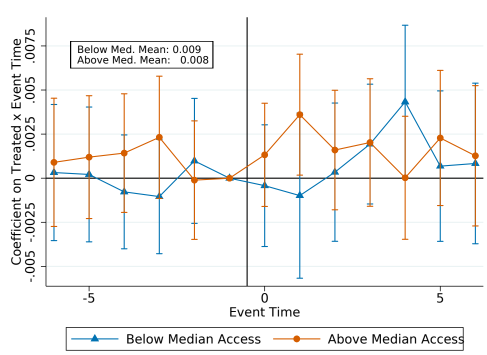
(a) Births in a County, Number of Adjacent Options



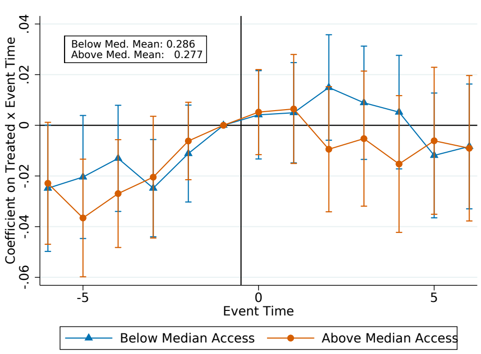
(b) Births in a County, Distance to Alternative



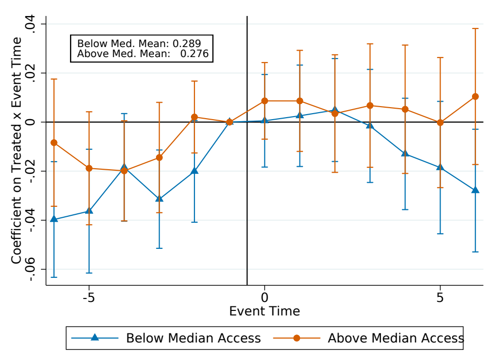
(c) Shares of Pregnancies with 1 or Fewer Prenatal Visits, Number of Adjacent Options



(d) Share of Pregnancies with 1 or Fewer Prenatal Visits, Distance to Alternative



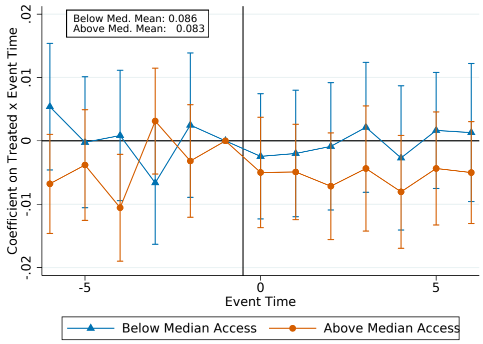
(e) Share of Births Induced, Number of Adjacent Options



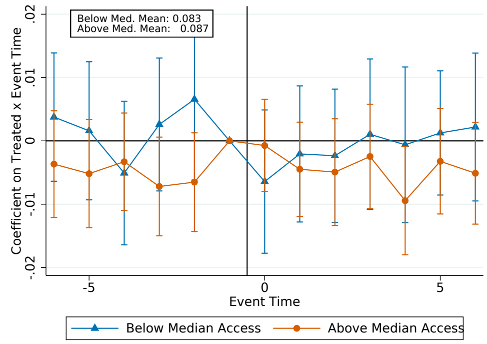
(f) Share of Births Induced, Distance to Alternative

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1) by above/below median access to alternatives. The dependent variable in Panels (a) - (b) is the number of births occurring in a county, in Panels (c) - (d) is the share of pregnancies with 1 or fewer prenatal visits, and in Panels (e) - (f) is the share of births induced. For each dependent variables, the sample is split above/below median based on access to available alternatives, measured as the number of hospitals with maternity wards in adjacent counties (Panels (a), (c), and (e)) or as the distance to the nearest hospital with a maternity ward (Panels (b), (d), and (f)). Observations are at the county-event time level and are clustered at the county level.

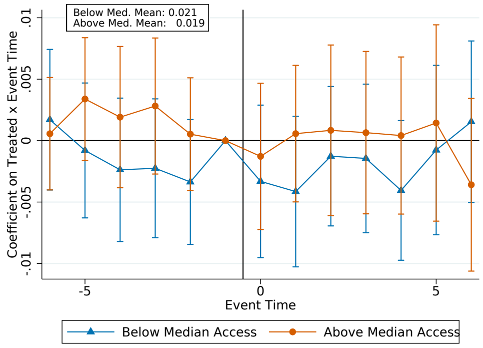
Figure A12: Estimated Impact of Closure by Access to Alternatives



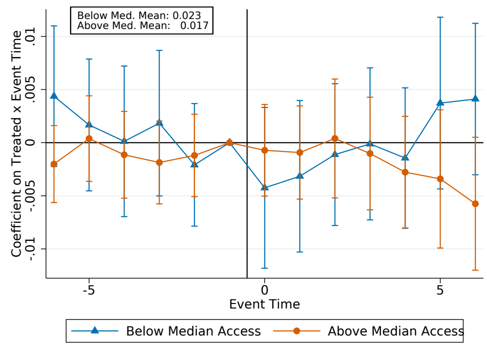
(a) Share of Births Low Birth Weight, Number of Adjacent Options



(b) Share of Births Low Birth Weight, Distance to Alternative



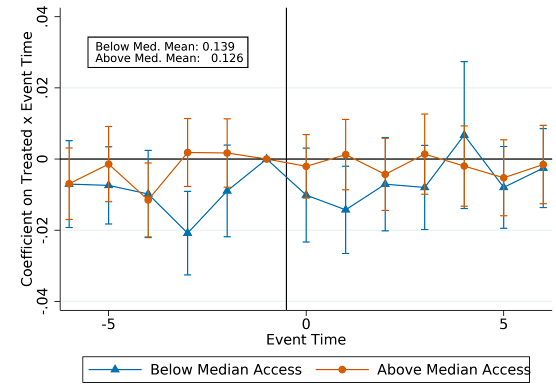
(c) Share of Births With Apgar ≤ 6, Number of Adjacent Options



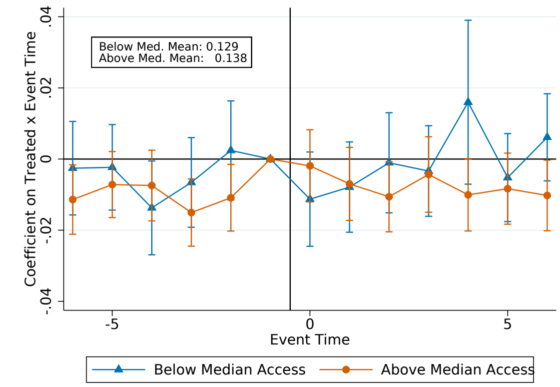
(d) Share of Births With Apgar ≤ 6, Distance to Alternative

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1) by above/below median access to alternatives. The dependent variable in Panels (a) - (b) is the share of births low birth weight and in Panels (c) - (d) is the share of births with an Apgar score less than or equal to 6. For each dependent variables, the sample is split above/below median based on access to available alternatives, measured as the number of hospitals with maternity wards in adjacent counties (Panels (a) and (c)) or as the distance to the nearest hospital with a maternity ward (Panels (b) and (d)). Observations are at the county-event time level and are clustered at the county level.

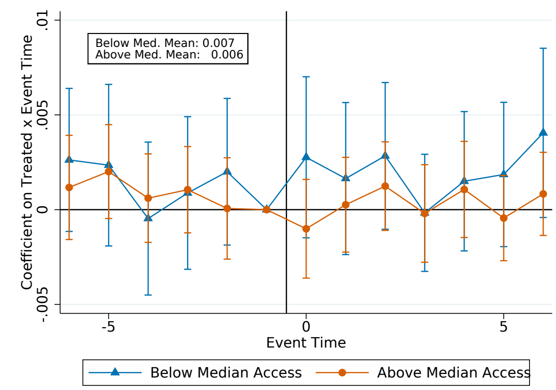
Figure A13: Estimated Impact of Closure by Access to Alternatives



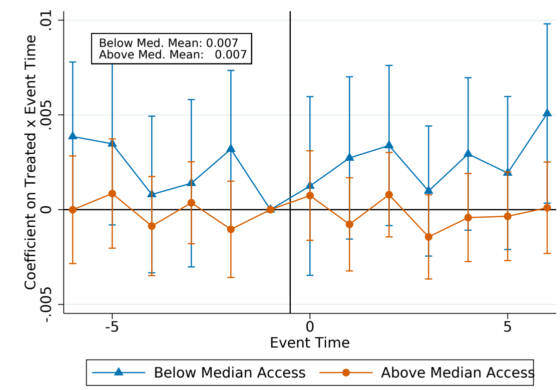
(a) Share of Births Preterm, Number of Adjacent Options



(b) Share of Births Preterm, Distance to Alternative



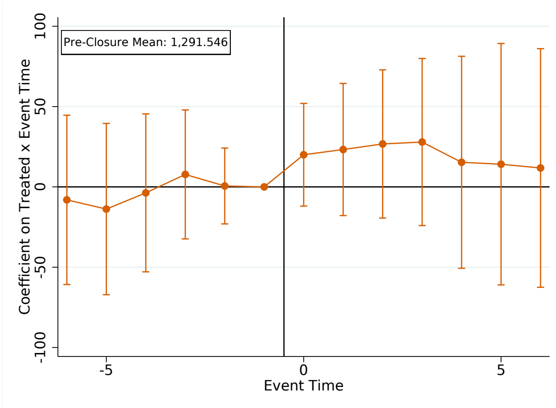
(c) Infant Mortality Rate, Number of Adjacent Options



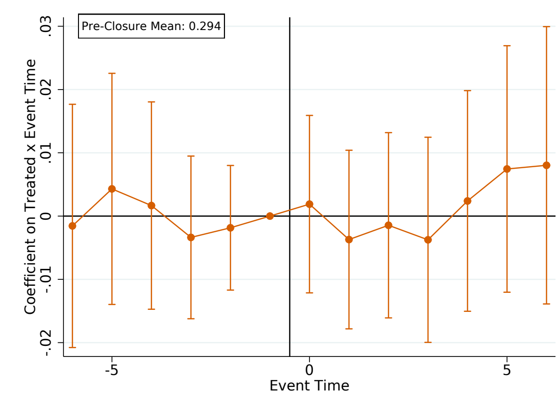
(d) Infant Mortality Rate, Distance to Alternative

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1) by above/below median access to alternatives. The dependent variable in Panels (a) - (b) is the share of births preterm and in Panels (c) - (d) is the infant mortality rate. For each dependent variables, the sample is split above/below median based on access to available alternatives, measured as the number of hospitals with maternity wards in adjacent counties (Panels (a) and (c)) or as the distance to the nearest hospital with a maternity ward (Panels (b) and (d)). Observations are at the county-event time level and are clustered at the county level.

Figure A14: Estimated Impact of Closure on County Births in Receiving Counties



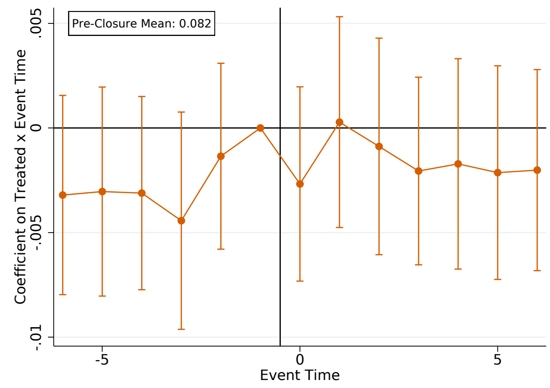
(a) Number of Births in County



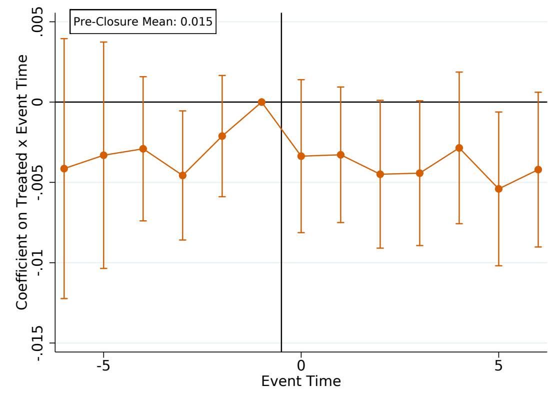
(b) Resident Births Occurring Out of County

Note: In Panels (a) and (b), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the number of births occurring within a county at event time τ and in Panel (b) is the share of births occurring to residents of a county occurring outside of the residence county. The sample consists of "receiving counties" as described in the text. Observations are at the county-event time level and are clustered at the county level.

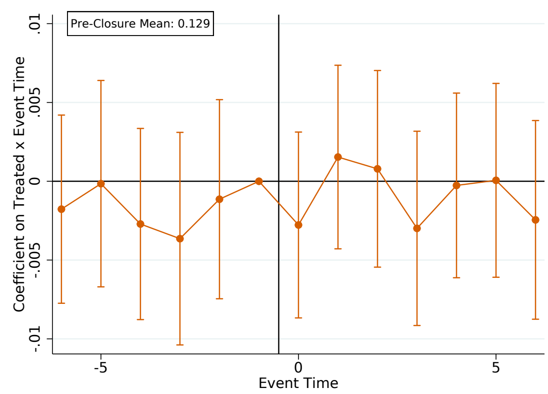
Figure A15: Estimated Impact of Closure on Infant Health in Receiving Counties



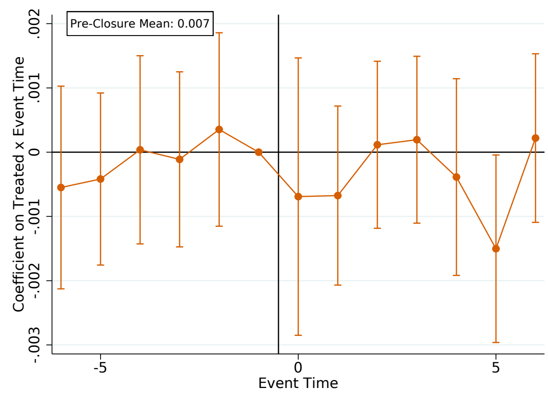
(a) Share of Births Low Birth Weight



(b) Share of Births With Apgar ≤ 6



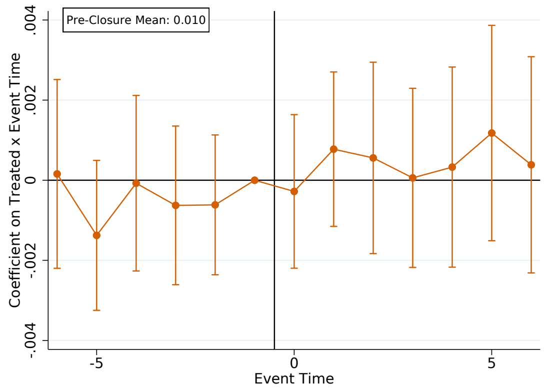
(c) Share of Births Preterm



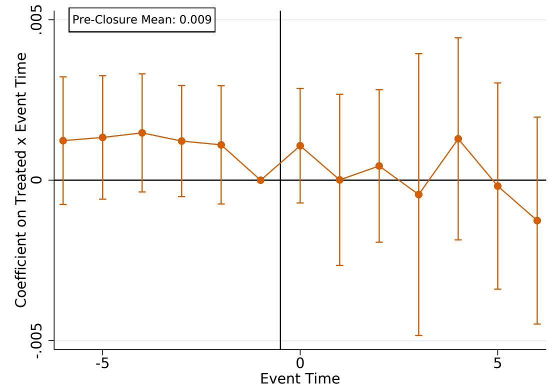
(d) Infant Mortality Rate

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births low birth weight (< 2500 grams), in Panel (b) is the share of births with an Apgar score of 6 or below, in Panel (c) is the share of births preterm (< 37 weeks gestation), and in Panel (d) is the infant mortality rate. The sample consists of "receiving counties" as described in the text. Observations are at the county-event time level and are clustered at the county level.

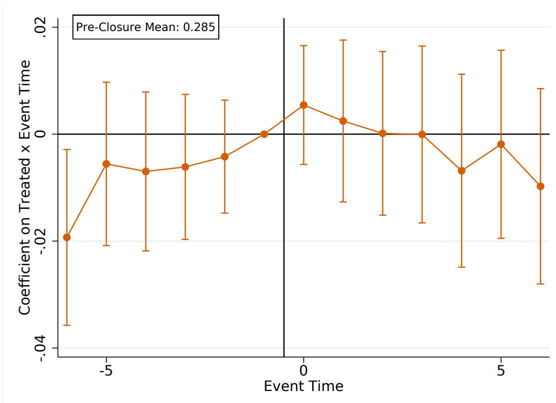
Figure A16: Estimated Impact of Closure on Characteristics of Pregnancy and Birth in Receiving Counties



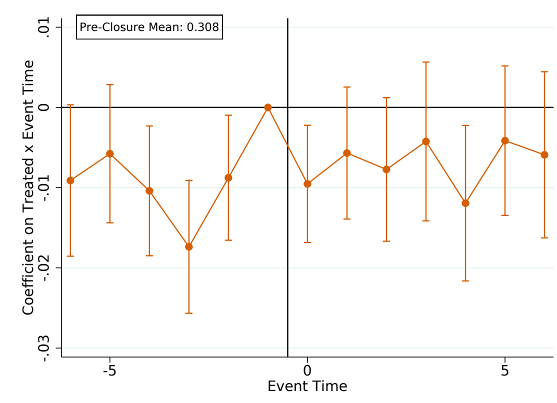
(a) Share of Births Out of Hospital



(b) Share of Pregnancies with 1 or Fewer Prenatal Visits



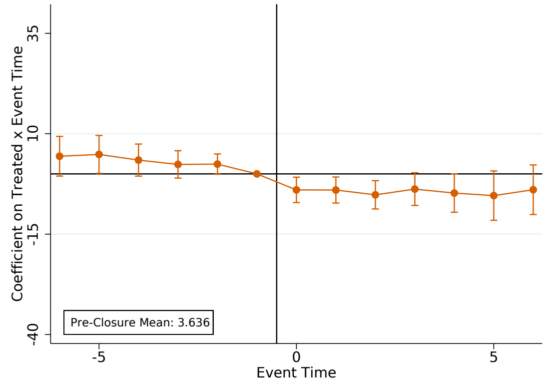
(c) Share of Births Induced



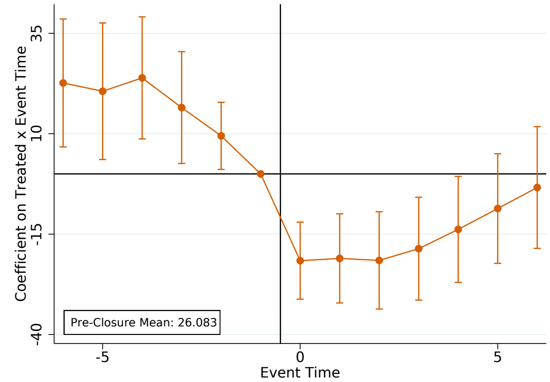
(d) Share of Births Delivered Via Cesarean

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable in Panel (a) is the share of births occurring outside of a hospital, in Panel (b) is the share of pregnancies with one or fewer prenatal visits, in Panel (c) is the share of births induced, and in Panel (d) is the share of deliveries that occur via a Cesarean. The sample consists of "receiving counties" as described in the text. Observations are at the county-event time level and are clustered at the county level.

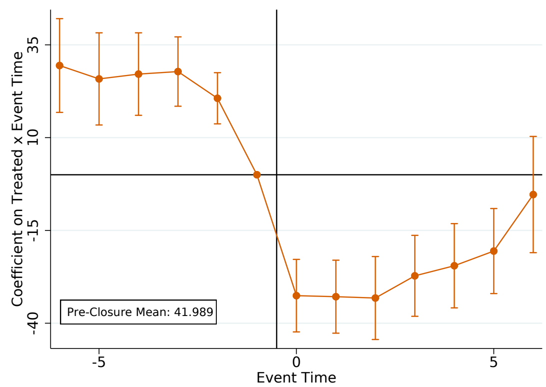
Figure A17: Estimated Impact of Closure on Births in a County by Subgroup



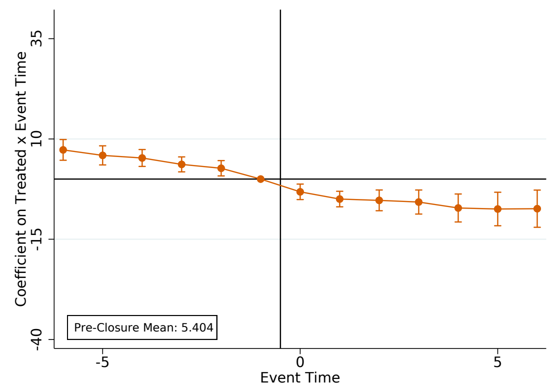
(a) Non-Black Hispanic



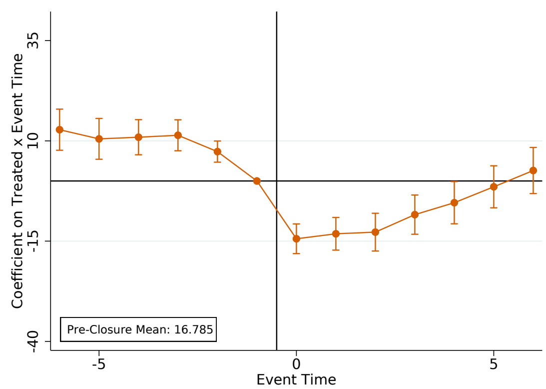
(b) Black



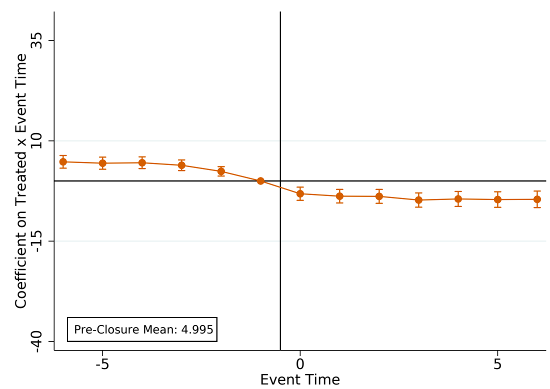
(c) HS or Below



(d) College or Above



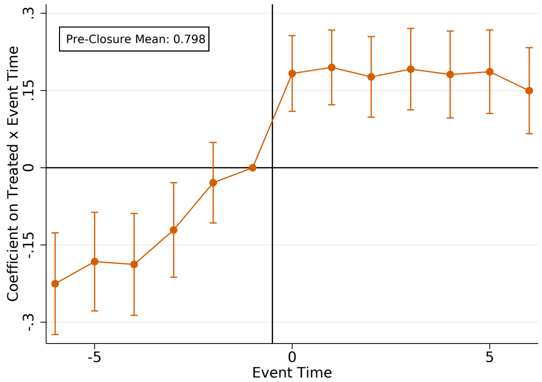
(e) Less Than 20 Years Old



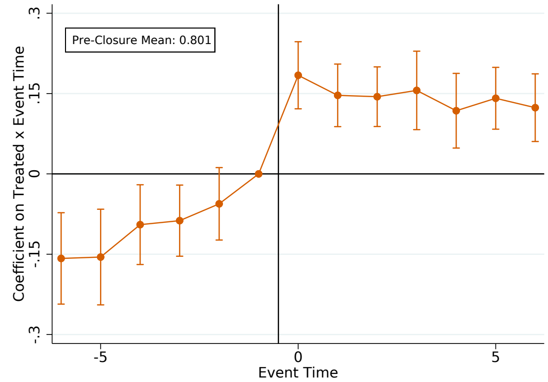
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the number of births occurring in a county. Each Panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

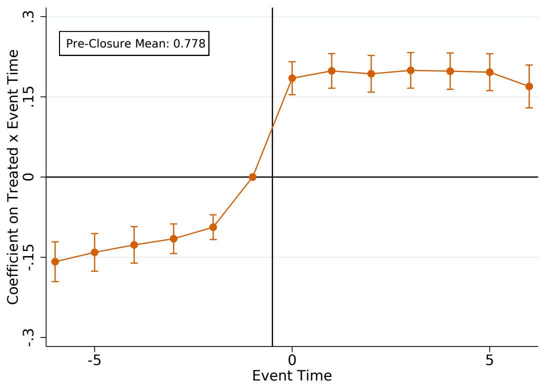
Figure A18: Estimated Impact of Closure on Out-of-County Birth by Subgroup



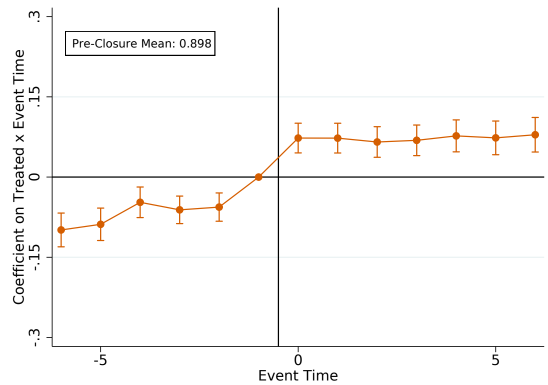
(a) Non-Black Hispanic



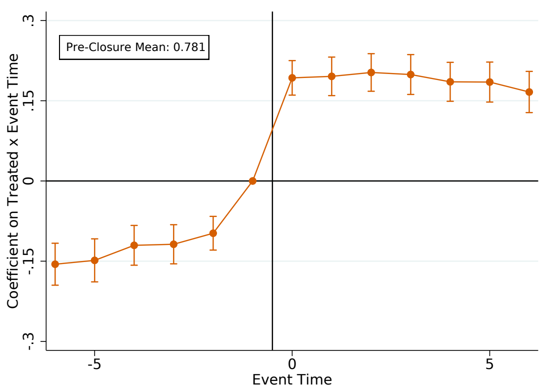
(b) Black



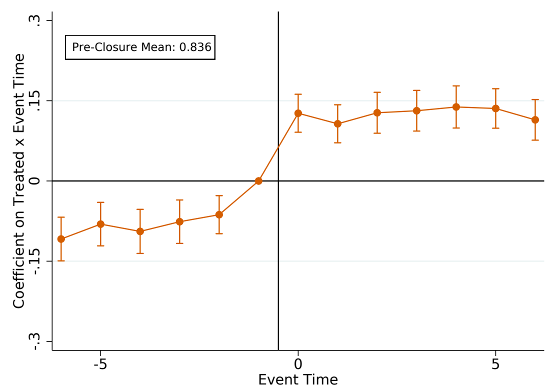
(c) High School or Below



(d) College or Above



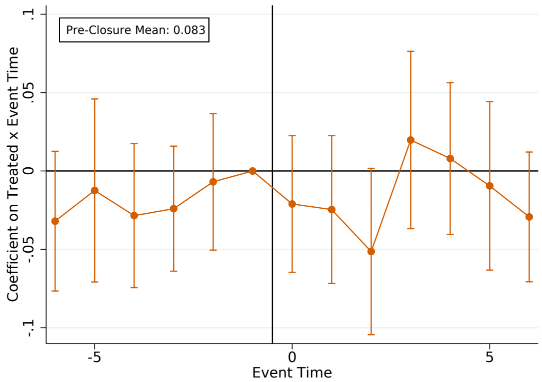
(e) Less Than 20 Years Old



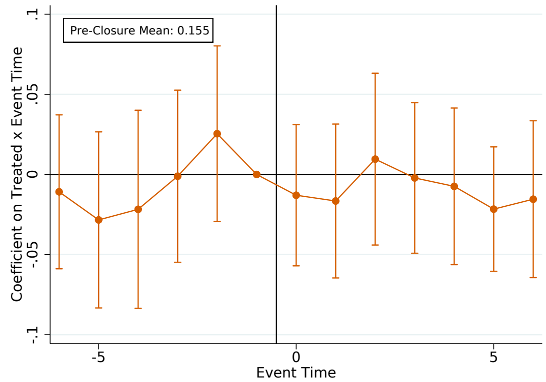
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births occurring out of county. Each Panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

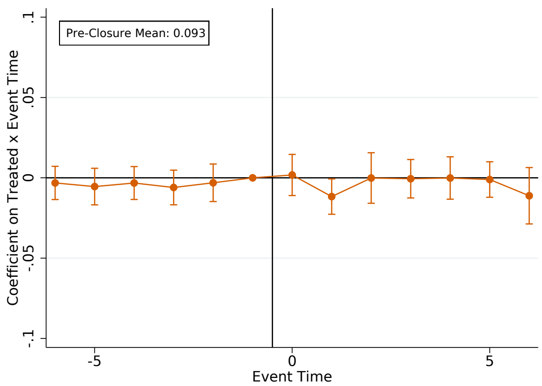
Figure A19: Estimated Impact of Closure on Share of Births Low Birth Weight by Subgroup



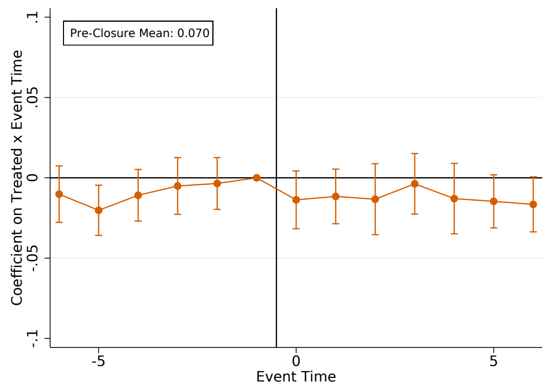
(a) Non-Black Hispanic



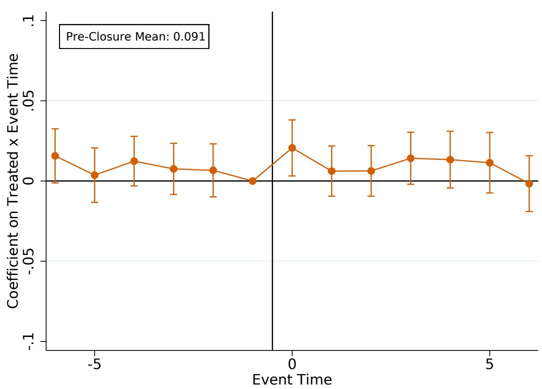
(b) Black



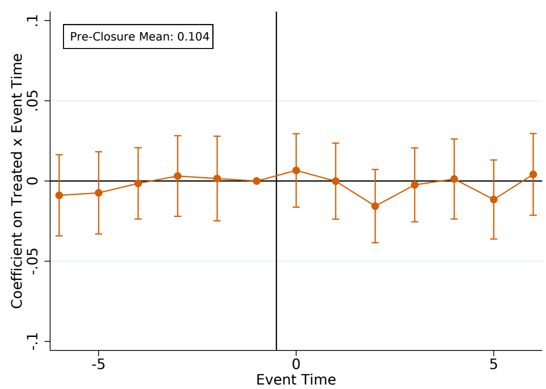
(c) High School or Below



(d) College or Above



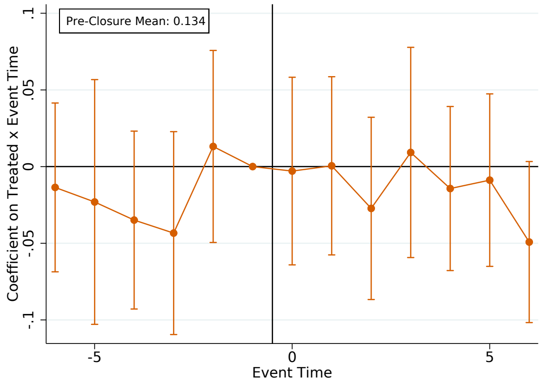
(e) Less Than 20 Years Old



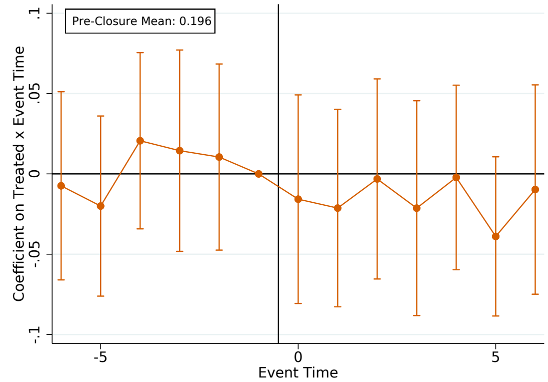
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births low birth weight. Each Panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

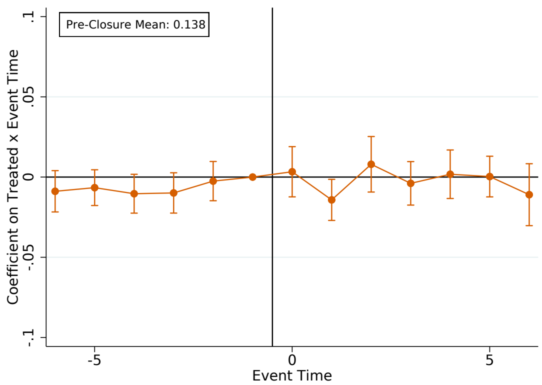
Figure A20: Estimated Impact of Closure on Share of Births Preterm by Subgroup



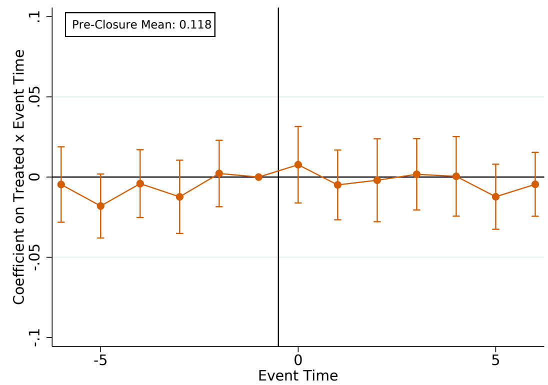
(a) Non-Black Hispanic



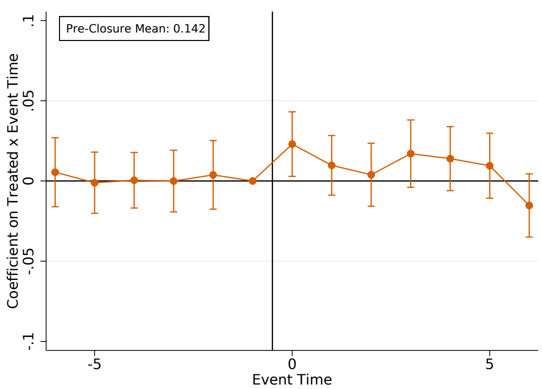
(b) Black



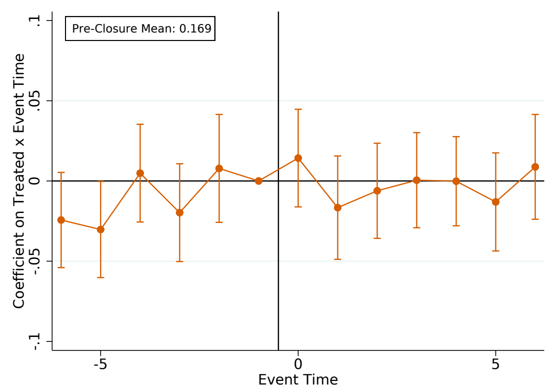
(c) High School or Below



(d) College or Above



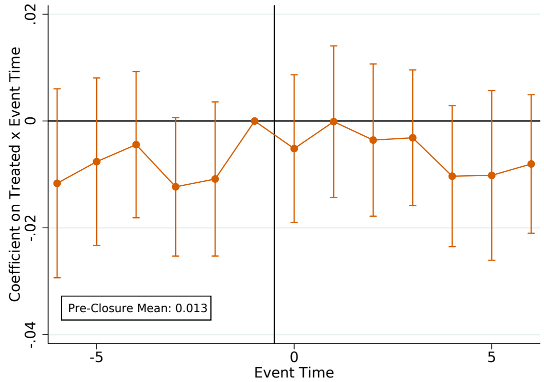
(e) Less Than 20 Years Old



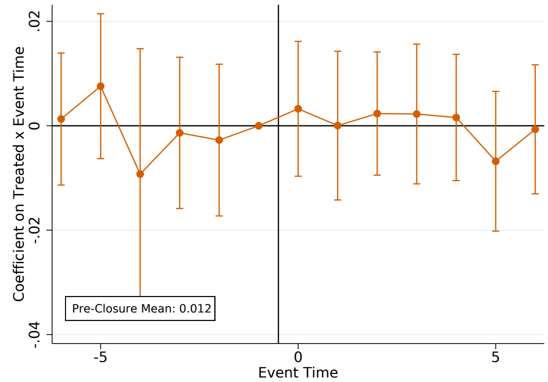
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births preterm. Each Panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

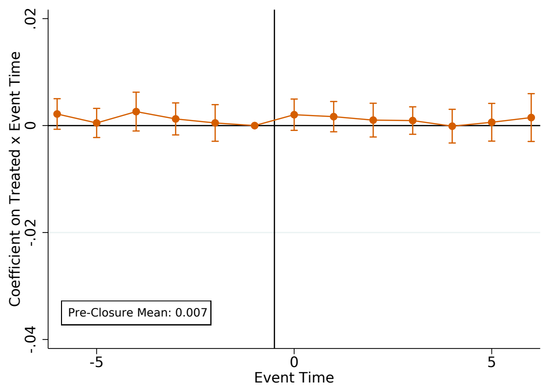
Figure A21: Estimated Impact of Closure on Infant Mortality Rate by Subgroup



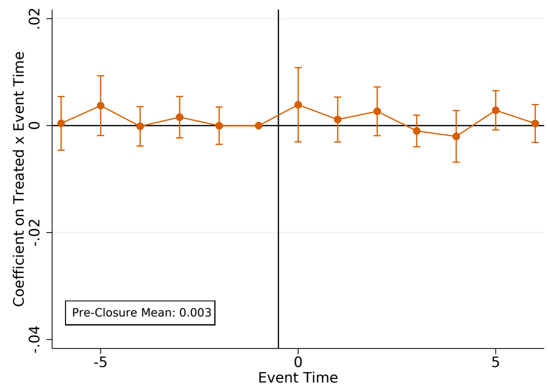
(a) Non-Black Hispanic



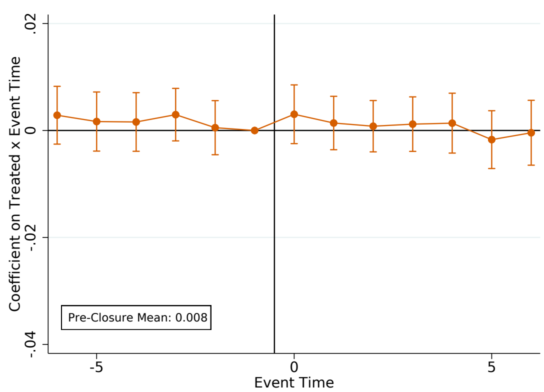
(b) Black



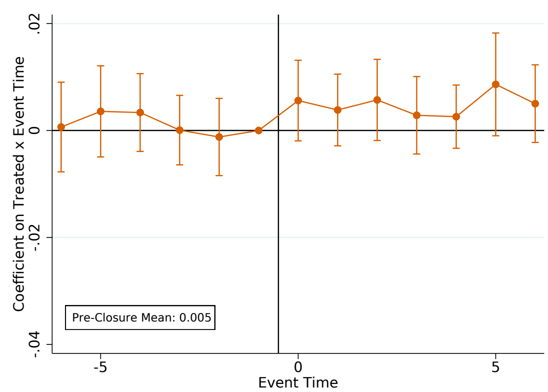
(c) High School or Below



(d) College or Above



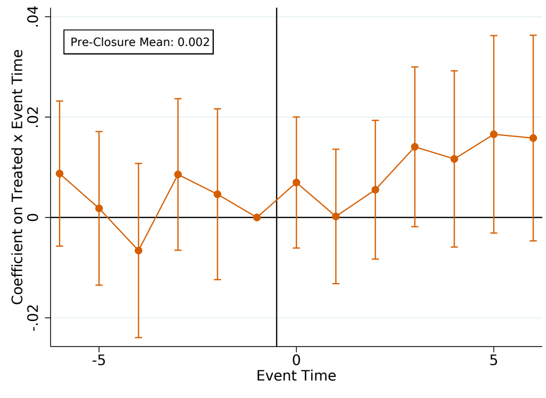
(e) Less Than 20 Years Old



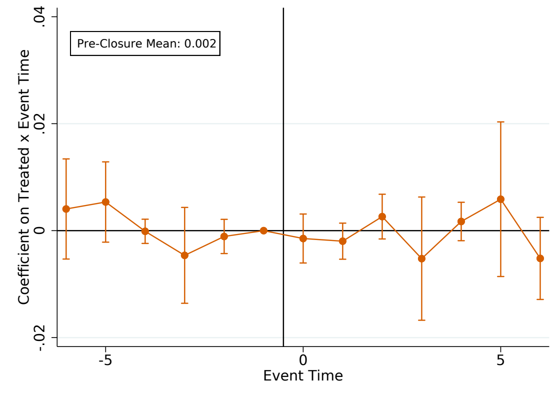
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the infant mortality rate. Each panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

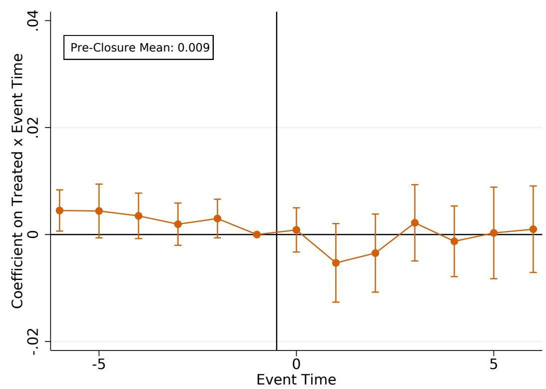
Figure A22: Estimated Impact of Closure on Out-of-Hospital Birth by Subgroup



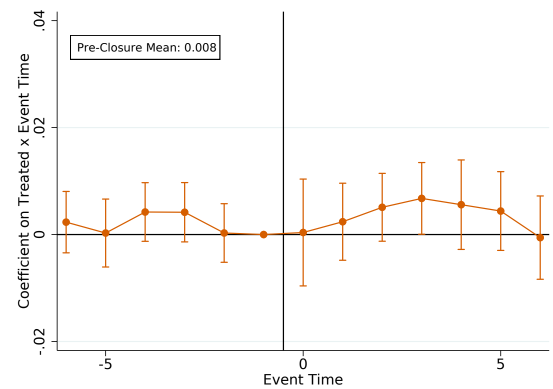
(a) Non-Black Hispanic



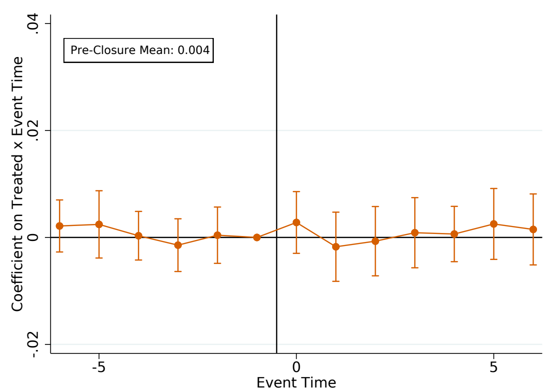
(b) Black



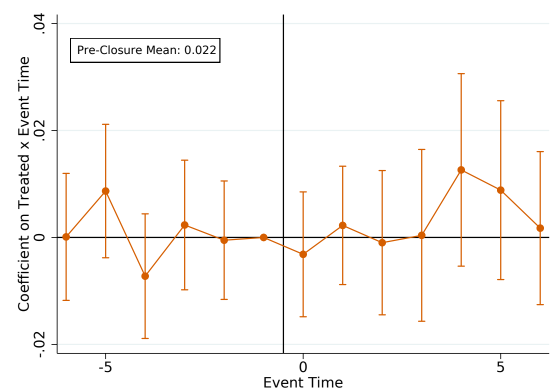
(c) High School or Below



(d) College or Above



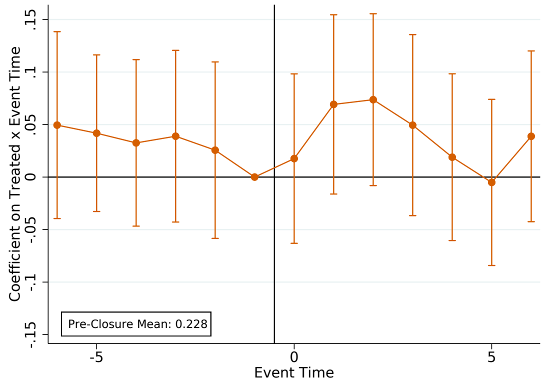
(e) Less Than 20 Years Old



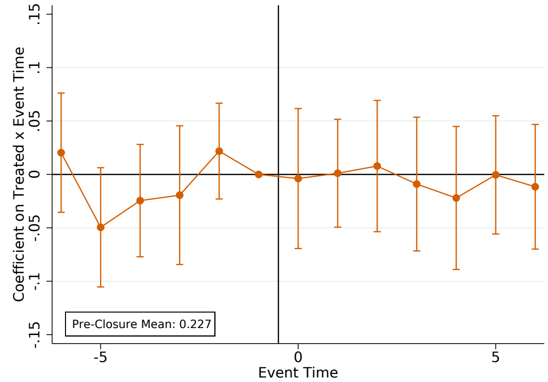
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births occurring out of hospital. Each panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

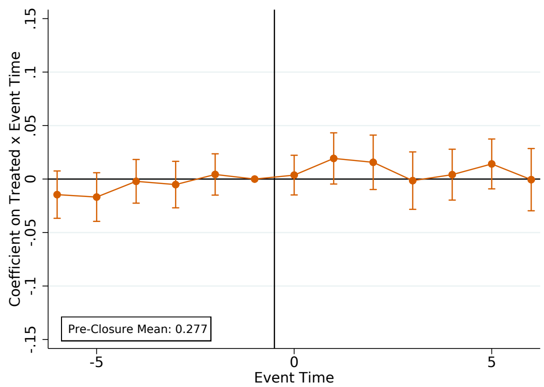
Figure A23: Estimated Impact of Closure on Share of Births Induced by Subgroup



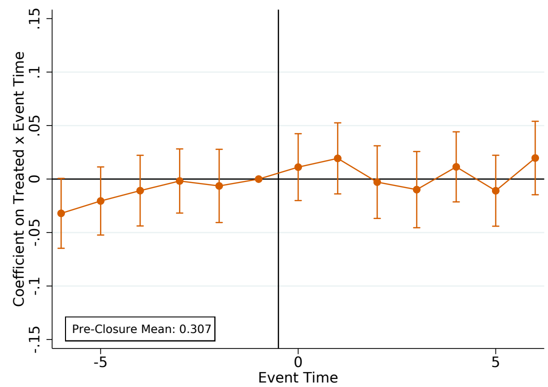
(a) Non-Black Hispanic



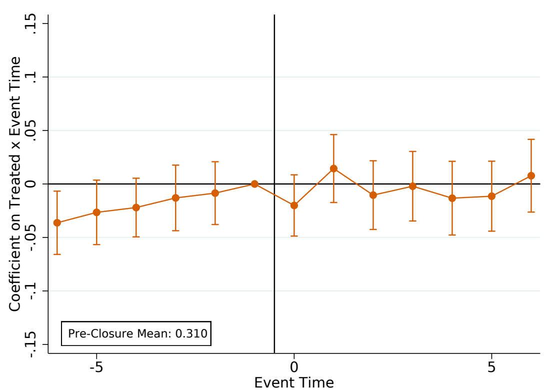
(b) Black



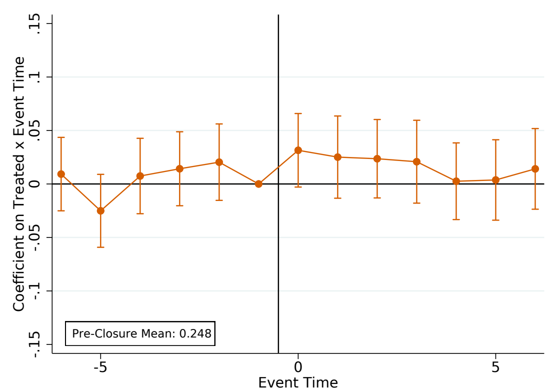
(c) High School or Below



(d) College or Above



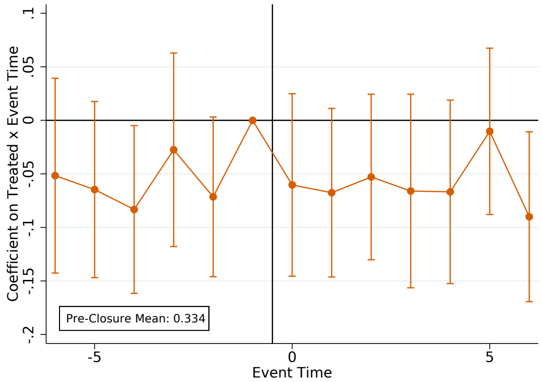
(e) Less Than 20 Years Old



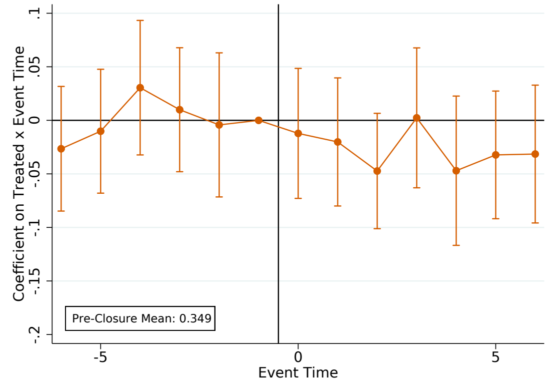
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births induced. Each Panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level

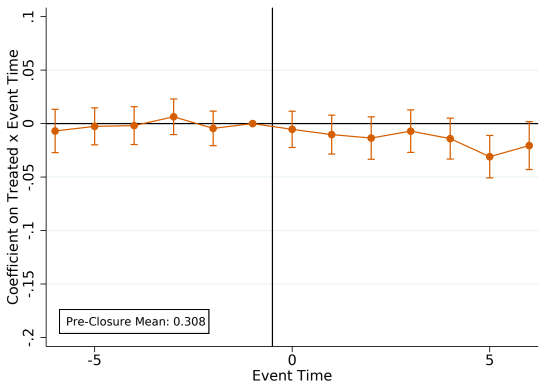
Figure A24: Estimated Impact of Closure on Cesarean Rate by Subgroup



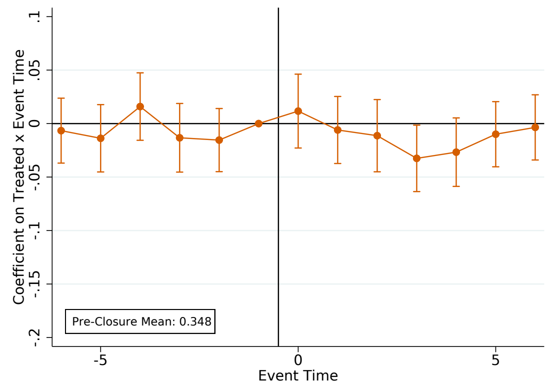
(a) Non-Black Hispanic



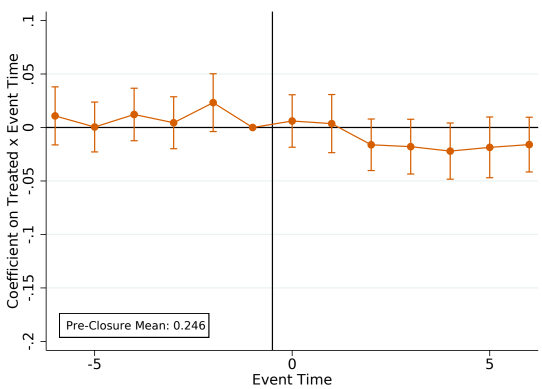
(b) Black



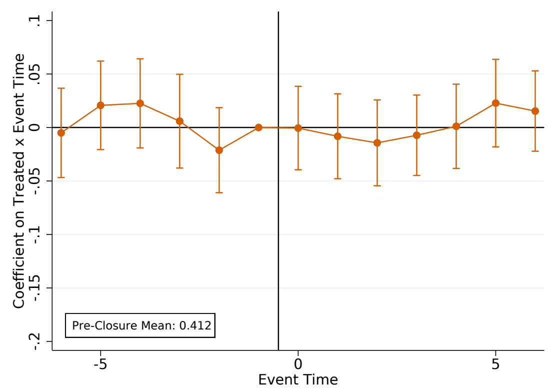
(c) High School or Below



(d) College or Above



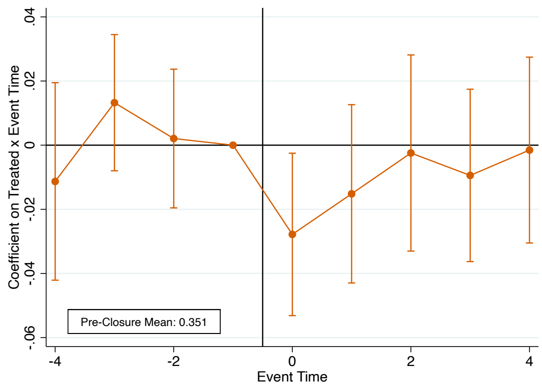
(e) Less Than 20 Years Old



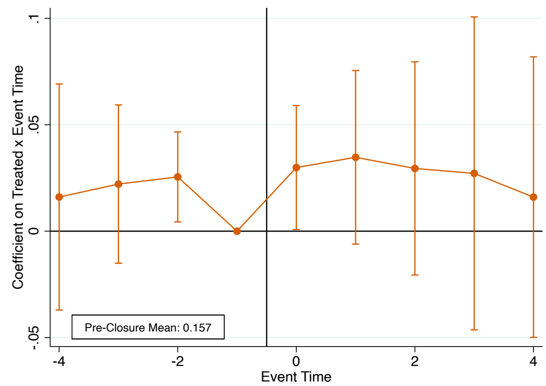
(f) More Than 35 Years Old

Note: In Panels (a) - (f), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (1). The dependent variable is the share of births delivered via Cesarean. Each panel is estimated on the sample of birth certificates from each county meeting the demographic characteristic listed. Observations are at the county-event time level and are clustered at the county level.

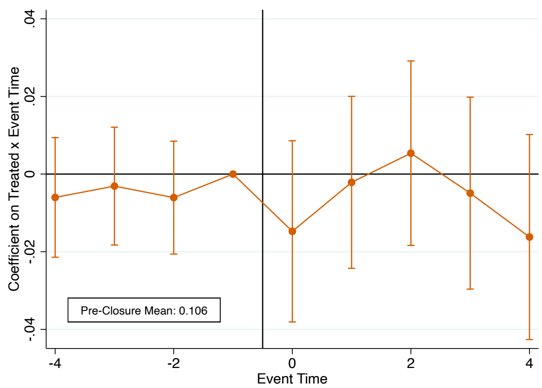
Figure A25: Estimated Impact of Closure on Maternal Outcomes, Largest Maternity Wards



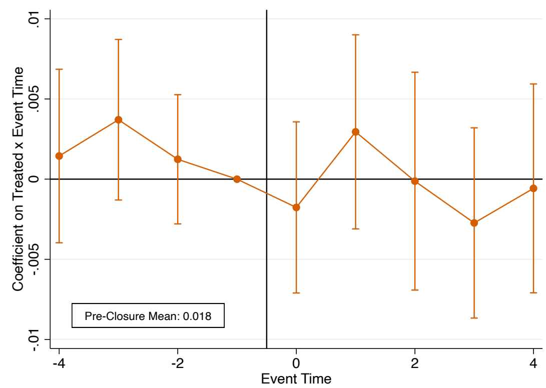
(a) Cesarean



(b) Induction



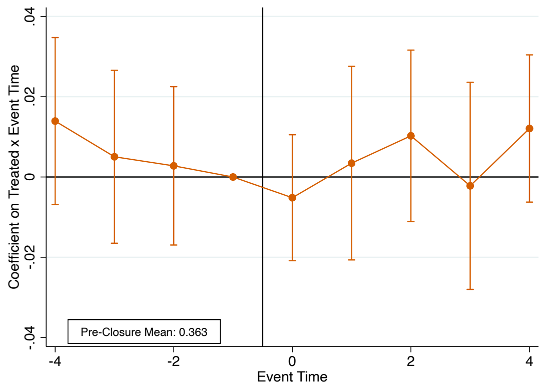
(c) Length of Stay > 3 Days



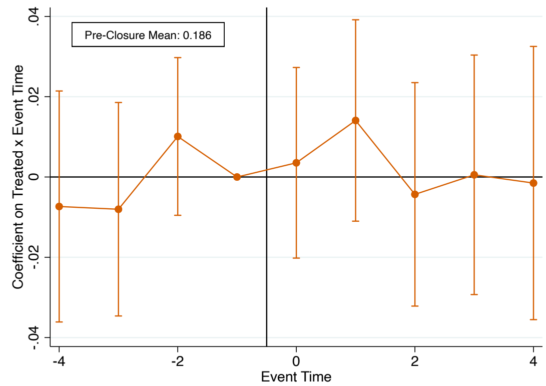
(d) Any Severe Maternal Morbidity

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (3). The dependent variable is an indicator for if a birth was delivered via Cesarean (Panel (a)), if the birth was induced (Panel (b)), if the length of stay was more than 3 days (Panel (c)), and if there were any severe maternal morbidities (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

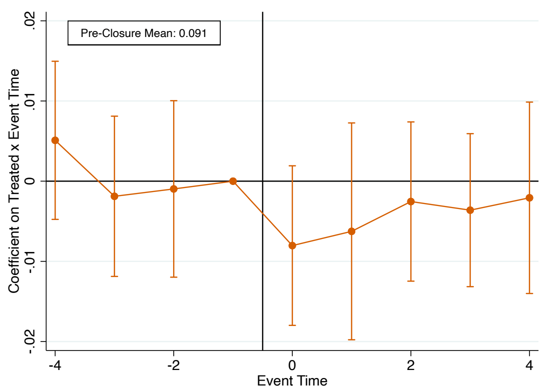
Figure A26: Estimated Impact of Closure on Maternal Outcomes, Smallest Maternity Wards



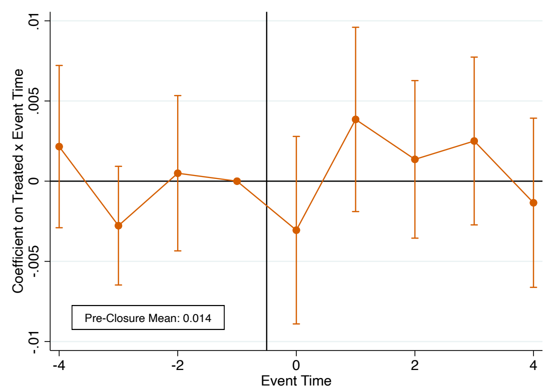
(a) Cesarean



(b) Induction



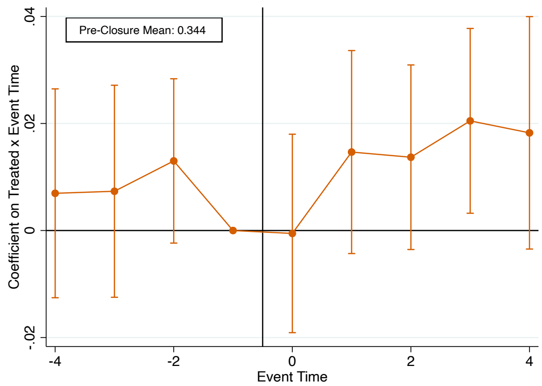
(c) Length of Stay > 3 Days



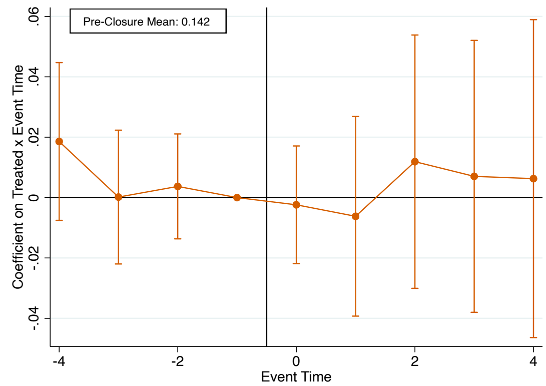
(d) Any Severe Maternal Morbidity

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (3). The dependent variable is an indicator for if a birth was delivered via Cesarean (Panel (a)), if the birth was induced (Panel (b)), if the length of stay was more than 3 days (Panel (c)), and if there were any severe maternal morbidities (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

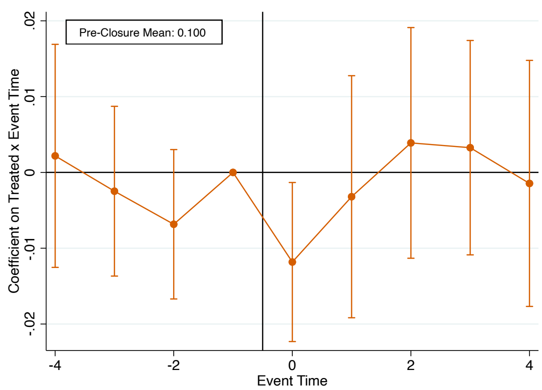
Figure A27: Estimated Impact of Closure on Maternal Outcomes in Receiving Hospitals, Below Median Exposure



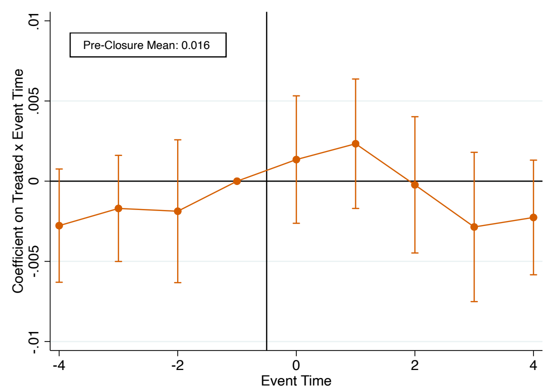
(a) Cesarean



(b) Induction



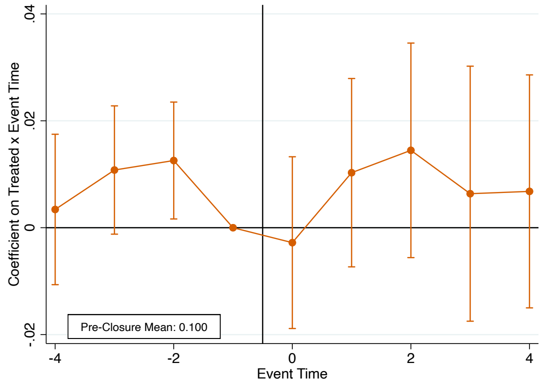
(c) Length of Stay > 3 Days



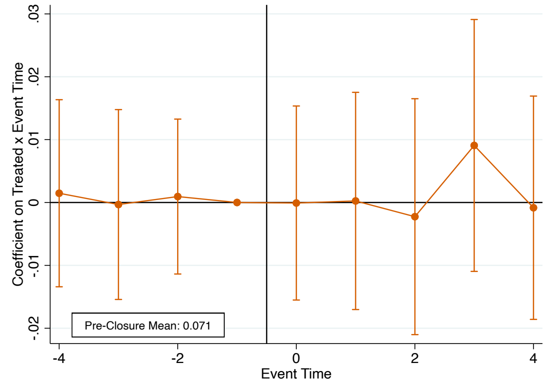
(d) Any Severe Maternal Morbidity

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the β_τ coefficient from estimating equation (3). The dependent variable is an indicator for if a birth was delivered via Cesarean (Panel (a)), if the birth was induced (Panel (b)), if the length of stay was more than 3 days (Panel (c)), and if there were any severe maternal morbidities (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

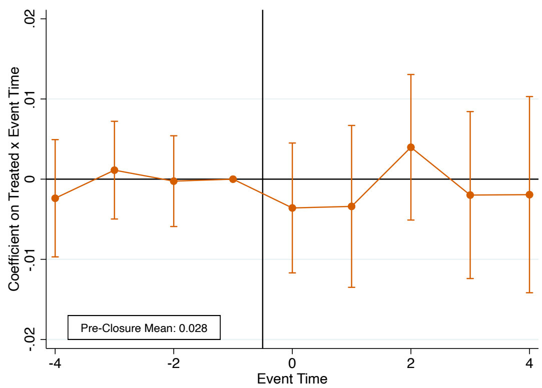
Figure A28: Estimated Impact of Closure on Infant Outcomes, Largest Maternity Wards



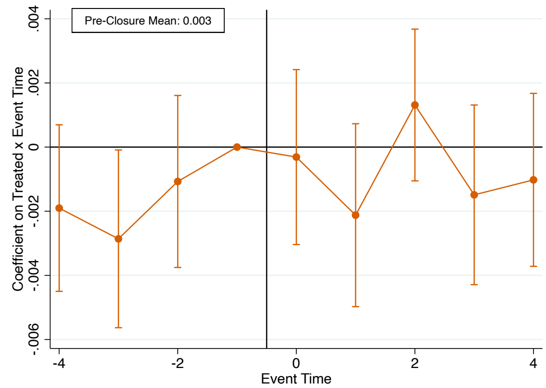
(a) Length of Stay > 3 Days



(b) Preterm Birth



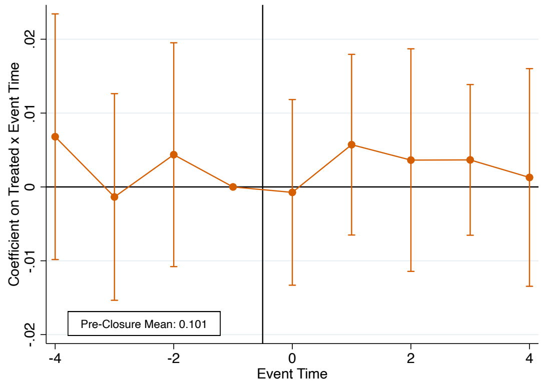
(c) Low Birth Weight



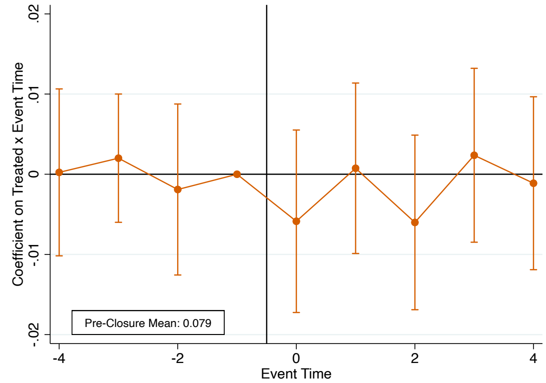
(d) Infant Mortality

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the β_τ coefficient from estimating equation (3). The dependent variable is an indicator for if the length of stay was more than 3 days (Panel (a)), if the birth was preterm (Panel (b)), if birth was low birth weight (Panel (c)), and if the newborn died during the initial hospital stay (Panel (d)). Sample is estimated on maternity wards that close with above-median births before closure. Observations are at the individual-event time level and are clustered at the zip code level.

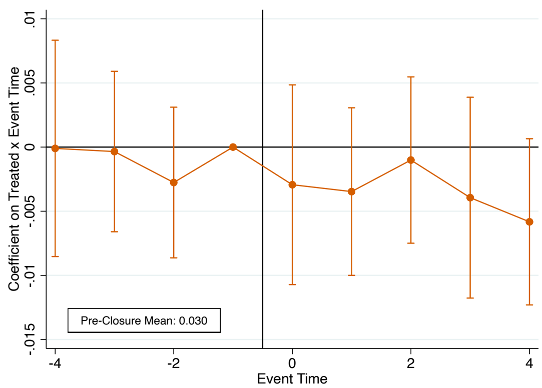
Figure A29: Estimated Impact of Closure on Infant Outcomes, Smallest Maternity Wards



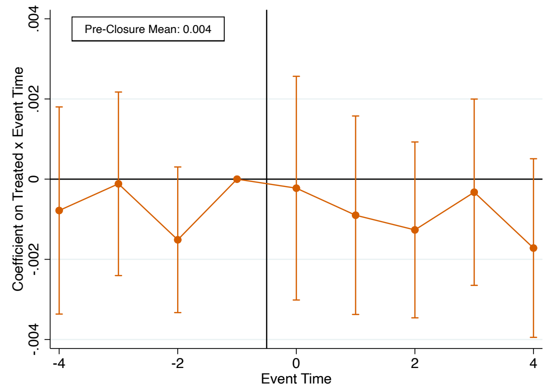
(a) Length of Stay > 3 Days



(b) Preterm Birth



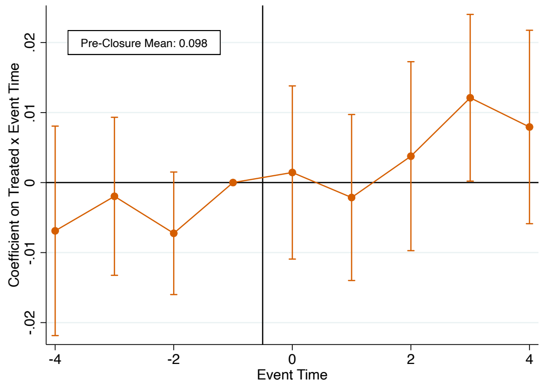
(c) Low Birth Weight



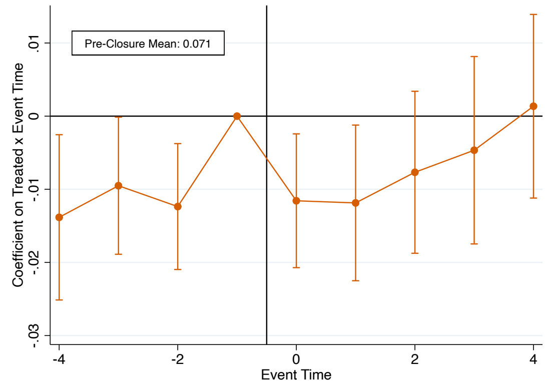
(d) Infant Mortality

*Note:*In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the β_τ coefficient from estimating equation (3). The dependent variable is an indicator for if the length of stay was more than 3 days (Panel (a)), if the birth was preterm (Panel (b)), if birth was low birth weight (Panel (c)), and if the newborn died during the initial hospital stay (Panel (d)). Sample is estimated on maternity wards that close with below-median births before closure. Observations are at the individual-event time level and are clustered at the zip code level.

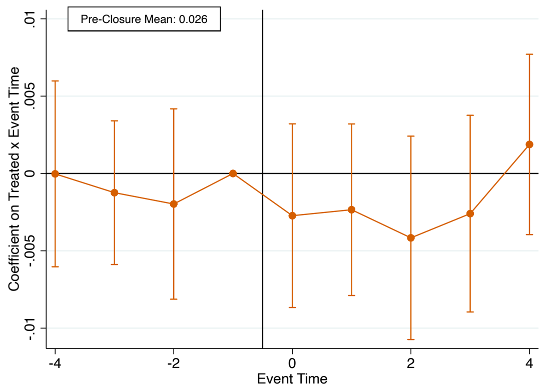
Figure A30: Estimated Impact of Closure on Infant Outcomes for Receiving Hospitals, Below Median Exposure



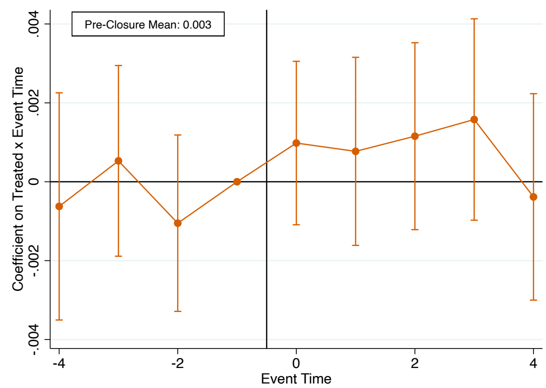
(a) Length of Stay > 3 Days



(b) Preterm Birth



(c) Low Birth Weight



(d) Infant Mortality

Note: In Panels (a) - (d), each point, and the associated 95 percent confidence interval, represents the treat-control difference from estimating equation (3). The dependent variable is an indicator for if the length of stay was more than 3 days (Panel (a)), if the birth was preterm (Panel (b)), if birth was low birth weight (Panel (c)), and if the newborn died during the initial hospital stay (Panel (d)). Observations are at the individual-event time level and are clustered at the zip code level.

Table A1: Summary Statistics by Hospital Category

	(1) Rural Closures	(2) Rural Non-Closures	(3) Texas Closures	(4) Receiving Hospitals
Bed Size	57.08	111.00	103.40	186.51
	(44.57)	(110.75)	(106.13)	(161.86)
Number of Births	108.59	523.64	499.22	870.34
	(119.87)	(642.68)	(665.24)	(960.34)
Has Neonatal ICU	0.00	0.03	0.02	0.14
	(0.00)	(0.17)	(0.14)	(0.35)
N	166	1091	58	286

Note: This table compares characteristics of hospitals in the sample. Column 1 displays characteristics of hospitals that were the sole provider of maternity care in their county in 2002 and close by 2012. Column 2 displays characteristics of hospitals that were the sole provider of maternity care in their county in 2002 and are still open in 2012. Column 3 displays characteristics of hospitals that provided maternity care in Texas in 2002 and close by 2012 (with no restriction on the number of providers in the county). Column 4 displays characteristics of hospitals that provide maternity care in the counties where women who experience a closure in the Vital Stats data go to following closure (the "receiving hospitals"). Hospital characteristics and provision of maternity care services are based on a hospital's self-report from the American Hospital Association's Annual Survey.

Table A2: Summary Statistics of Matched Treatment and Control Counties

	(1) Treated	(2) Control
Population	20,858	23,552
	(15,406)	(14,641)
% Female 18-44	19.9	20.0
	(2.0)	(20.1)
% Black	9.7	8.3
	(16.9)	(14.5)
% College	18.7	18.3
	(4.9)	(4.6)
Unemployment Rate	6.1	6.4
	(2.9)	(3.2)
Number of Establishments	433	497
	(278.4)	(271.9)
Per Capita Income	17,631	17,572
	(2,383)	(2,251)
Per Capita Transfers	3,652	3,651
	(630.3)	(620.1)
N	190	190

Note: This table reports descriptive statistics of counties that experience a complete loss in maternity care services (treated counties) and their matched control counties. Counties are matched using propensity score matching as described in the text. Summary statistics are computed based on characteristics of the county in 1995.