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**IMPACTS OF RESTRICTIVE ABORTION LEGISLATION ON PREGNANCY OUTCOMES AT A SAFETY NET HOSPITAL IN ATLANTA, GEORGIA**

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B.A., The University of Michigan, 2017

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# Abstract

## IMPACTS OF RESTRICTIVE ABORTION LEGISLATION ON PREGNANCY OUTCOMES AT A SAFETY NET HOSPITAL IN ATLANTA, GEORGIA

By Hannah Marcovitch

**Introduction:**
Following the Dobbs decision in 2022, Georgia's House Bill 481 (HB481), a ban limiting abortion after approximately 6 weeks, went into effect. To date, no study has explored the law's impacts on key clinical indicators of maternal morbidity and mortality.

**Objective:**
The purpose of this study was to examine whether enactment of HB481 has been associated with changes pregnancy-related morbidity at a safety net hospital in Atlanta, Georgia to better characterize risks to pregnancy after the law went into effect.

**Methods:**
We conducted a population-based study of all pregnancies with documented deliveries or miscarriages managed at Grady Memorial Hospital between July 2021 and July 2023. The primary outcomes of interest in this study were miscarriage diagnosis, early pregnancy complication (between 6 and 22 weeks EGA), and pregnancy complication throughout gestation during this period. Trends in each of these outcomes were evaluated over the course of the study period using an interrupted time series retrospective study design with Poisson regression. Secondary outcomes of interest for this study included cause-specific miscarriage diagnoses, cause-specific maternal morbidity, perinatal outcomes, and CDC-defined severe maternal morbidity (SMM).

**Results:**
A total of 3,754 unique pregnancies were included in the study. In the 24,326 pregnancy-months of data, 7,614 occurred in the six months after enactment and 16,712 in the year before. The rate of miscarriage diagnosis (RR 1.10, 95% CI 0.77, 1.56) and pregnancy complication at any gestational age (RR 1.05, 95% CI 0.98, 1.12) did not change after vs. before HB481 went into effect. The rate of early pregnancy complication (RR 1.28, 95% CI 0.86, 1.91) demonstrated trend toward increasing after vs. before that may have clinical relevance.

**Conclusions:**
Given the already unacceptably high rates of maternal morbidity in Georgia and existing challenges in access to pregnancy care in the state; HB481 is a further threat to healthy pregnancy and sits in direct opposition to Georgians' reproductive justice. It remains essential that researchers document the health impacts of this legislation as it remains in effect, with particular attention to populations most at risk of harm. Further, with laws similar to HB481 in effect in states across the United States, studies with similar objectives to this one must continue to document the direct health impacts of restrictive abortion policy on pregnancy outcomes nationwide.

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## Introduction

Safe, legal and accessible abortion is a necessary component of reproductive healthcare.[1-3] The Supreme Court's overturning of Roe vs. Wade with its decision in the Dobbs vs. Jackson Women's Health Center has provoked rapid changes to the US healthcare landscape. In Georgia specifically, on July 20, 2022 a federal appeals court allowed the state's House Bill 481 (HB 481) to go into effect for the first time since it passed state legislature in March 2019.[4] Georgia's law prohibits abortion in the presence of detectable fetal cardiac activity, with the exception of pregnancies considered "medically futile", "medical emergency", or in the case of rape or incest that has been reported to legal authorities.[5,6] Fetal cardiac activity typically occurs around 6-weeks gestational age, before many people are aware of their pregnancy. Prior to enactment of HB 481, abortion was legal in Georgia until 22-weeks gestational age.[7] The state has long served as a hub for those seeking abortion from throughout the Southeastern US.[8,9]

The direct health impacts of decreased abortion access are not fully understood and are unfolding in real time as this policy remains in effect. Previous work has shown that increasingly restrictive state abortion law is positively associated with increasing maternal and infant mortality as compared to supportive abortion legislation.[10] Recent national data have shown that since the Dobbs decision came down, documented abortions have sharply decreased in states with restrictive legislation, while remaining steady or increasing nationally.[11] During this same period, live births in states with restrictive abortion legislation have increased at a higher rate as compared to those with permissive legislation.[12]

Prior to enactment of HB 481, clinicians in Georgia were able to offer either expectant management or pregnancy termination to those presenting with pregnancy complications before 22 weeks gestational age.[13] Under HB 481, this standard of care is no longer available, and clinicians now must wait until a pregnancy complication meets the poorly defined threshold of "medical emergency" before intervening. This places pregnant people at high risk of preventable morbidity and mortality. It also bars clinicians from offering evidence-based management.[14] Two safety net hospitals in Dallas, Texas documented the impacts of Texas's six-week abortion ban – the first of its kind to go into effect, in September 2021. Their work suggests significant rises in maternal morbidity for those with indications for delivery before 22-weeks gestational age.[15]

Restrictions to legal abortion are structural determinants of health that carry unequal impacts along racial and economic lines.[2,16] Owing to legacies of racism and economic injustice, abortion restrictions disproportionately affect pregnant people who are Black, Indigenous, and lower income.[17-19] Further, abortion is safer than pregnancy. In Georgia specifically, the state's previous 22-week gestational age abortion limit disproportionately impacted pregnant people who were Black after its enactment in 2012.[20,21] New restrictions will likely serve not only to amplify existing inequities in access to abortion but also to compound the already disparate rates of maternal morbidity and mortality, particularly among Black women in Georgia.[22-24]

In this changed landscape, and with many laws similar to HB 481 being enacted in states across the US, it will be increasingly important to document the impact on pregnancy outcomes when expectant management is often the only option for those presenting to clinical care with pregnancy complications between 6- and 22-weeks gestational age. To date, no study has explored the impacts of HB 481 on key clinical indicators of maternal morbidity and mortality in Georgia. Therefore, we seek to explore whether enactment of HB 481 has been associated with a change in key indicators of pregnancy-related morbidity at a safety net hospital in Atlanta, GA, aiming to better characterize risks to pregnancy after the law went into effect.

## Methods

*Study cohort and data collection*

We conducted a population-based study of all pregnancies with documented outcomes at Grady Memorial Hospital in Atlanta, GA between July 2021 and July 2023. Grady Memorial Hospital functions as an urban safety net institution for medically underserved patients residing in Georgia's Fulton and DeKalb counties.[25,26] The data for this study came from a longitudinal, automated electronic medical record abstraction system at Grady that includes information on inpatient and outpatient diagnostic and procedure codes, laboratory data, medication orders, obstetric and surgical history, and other patient characteristics. This database is intended to help form a comprehensive picture of health outcomes across the pregnancy and postpartum period among Grady patients.[27] This study included only pregnancies cared for by Emory University clinicians, who provide approximately 70% of patient care at the hospital.[26]

Our study included all pregnancies with documented outcomes at Grady between August 1, 2021 and July 31, 2023. This timeframe represents one year leading up to and six months following enactment of Georgia's HB 481, on July 21, 2022. Documented pregnancy outcomes were defined as deliveries or miscarriages managed during the specified timeframe. Comorbid conditions were characterized using Leonard et al.'s recently developed obstetric comorbidity scoring system and were extracted from the electronic health record using the *International Classification of Diseases,* Tenth Revision (ICD-10) codes laid forth by the authors.[28]

Data was extracted from the electronic health record (EHR) at the level of the healthcare encounter. To evaluate outcomes at the level of the pregnancy, we created a unique identifier for each pregnancy. First each medical record number (MRN) with a single encounter included in the dataset was automatically assigned one unique pregnancy ID. Subsequently, for all patients with multiple encounters included in the dataset, medical charts were analyzed to ascertain whether the encounters pertained to a single pregnancy (including follow-up for miscarriage management) or were related to visits for multiple different pregnancies during the study timeframe.

*Outcomes*

The primary outcomes of interest in this study were miscarriage diagnosis, early pregnancy complication, and overall pregnancy complication. We defined early pregnancy complication as at least one of the following occurring between 6-22 weeks gestational age: miscarriage-associated diagnosis, preterm prelabor rupture of membranes (PPROM), fever, antepartum hemorrhage, clinical chorioamnionitis, and any severe maternal morbidity event (SMM, as defined by the CDC).[29] "Early pregnancy" was defined for the purpose of the study as 6-22 weeks estimated gestational age (EGA). This represents the timeframe of pregnancy during which HB 481 most directly altered the scope of pregnancy care available. Pregnancy complication at any EGA was defined as these same outcomes occurring any time throughout pregnancy. Miscarriage-associated diagnoses include threatened abortion, complete and incomplete spontaneous abortion, and missed abortion. Secondary outcomes of interest for this study included cause-specific miscarriage diagnoses, cause-specific maternal morbidity and perinatal outcomes (all outcomes examined can be found in supplemental materials), and CDC-defined SMM.[29] All ICD-10 codes used to abstract data can be found in the supplemental materials.

*Statistical analysis*

We used $\chi^2$ tests, paired t-tests and Fisher's exact tests to compare the distribution of demographic and clinical characteristics between pregnancy encounters during the pre-HB 481 vs. post-HB 481 periods. We calculated monthly rates for each outcome of interest by dividing the number of pregnancies with the outcome by the total number of active pregnancies occurring each month. The number of active pregnancies per month was calculated using each pregnancy's latest admission date that appeared in our dataset and its associated EGA. From this data, an active period for each pregnancy was calculated, ending at the pregnancy's delivery or miscarriage date. This calculation of pregnancy-months served as the denominator in calculating rate of each outcome of interest.

We used an interrupted time series quasi-experimental study design with segmented Poisson regression to estimate rate ratios (RRs) and 95% confidence intervals (CIs) comparing rates of each outcome before the legislation's enactment (August 1, 2021 through August 1, 2022) and after (August 1, 2022 through January 31, 2023). For all models, we assumed a priori no lag and a level change and slope change, given the immediate changes to obstetric care ushered in by the enactment of HB 481 on July 21, 2022. For each of the outcomes of miscarriage diagnosis, early pregnancy complication and overall pregnancy complication, overdispersion was detected based on a dispersion parameter >1. Each model was therefore corrected by using a scaled parameter. Durbin-Watson tests were performed to evaluate for first-order autocorrelation between the model-based residuals of adjacent observations. Based on the Durbin-Watson test statistics and residual plots for miscarriage diagnosis, early pregnancy complication, and overall pregnancy complication, no significant autocorrelation was detected. Therefore, models were not adjusted for autocorrelation. To assess our assumption of no lag, we performed a sensitivity analysis excluding all pregnancies 3 months after the date HB 481 went into effect. No significant differences were noted.

Age, race, ethnicity, parity, and insurance status were the demographic variables evaluated for confounding by testing for a statistical association with the exposure (time) and each of the outcomes in interest, being miscarriage, early pregnancy complication and pregnancy complication at any gestational age. No evidence of such confounding by demographic variables was observed. We considered August 1, 2022 as the cutoff date. The models indicated a binary indicator of the timing of the pregnancy (before vs. after enactment of HB 481), a continuous measure of time before/after enactment of HB 481 (centered on cutoff date), the interaction of these two variables and the confounders listed above. The only variables with missing data were estimated gestational age, race/ethnicity and parity. All missing EGAs (n=522) were abstracted manually from the electronic health record to be able to accurately ascertain outcomes of interest. R version 4.2.2 was used for analysis. This study was approved by the Emory Institutional Review Board and Grady Memorial Hospital's Research Oversight Committee.

## **Results**:

A total of 3,754 unique pregnancies with documented outcomes at Grady were included in the analysis. 3,151 pregnancies were active in the pre-HB481 enactment period and 1,868 were active in the post-enactment period (Table 1). 1,265 pregnancies were active in both periods. This data includes a total of 24,326 pregnancy-months of data, including 16,712 between August 1, 2021 and July 31, 2022 and 7,614 between August 1, 2022 and January 31, 2023.

Demographic and clinical characteristics of our study population are shown in Table 1. Most pregnancies (>71%) included in our study population were among Black patients. The proportion of pregnancies in Latino patients was approximately the same between periods, at

20.2% prior to legislative enactment to 20.9% post (p=.41). The proportion of pregnancies among people who were publicly insured decreased in the post-enactment period from 80.4% to 77.7%. The proportion of self-pay encounters accounted for a small proportion of the population that remained stable at 0.1%, and privately insured encounters increased from 13.7% to 15.0% (p=.12). Median Leonard comorbidity scores, both transfusion-associated and not, were the same in the pre- and post-enactment periods. The transfusion-associated median comorbidity score was 11 in both periods and the median non-transfusion-associated score was 6.

**Table 1**
Demographic and Clinical Characteristics of Pregnancies Before and After Enactment of HB481

| Characteristic | Pre-HB 481 (August 1, 2021, to July 31, 2022)<br><br>N=3151 pregnancies | Post-HB 481 (August 1, 2022, to January 31, 2023)<br><br>N=1868 pregnancies | P-value |
|---|---|---|---|
| | **N** | **N** | |
| No. pregnancy-months | 16869 | 11073 | |
| No. of deliveries | 1458 (46.3) | 800 (42.8) | |
| | **Mean (SD)** | **Mean (SD)** | |
| Mean maternal age | 28.06 ± 6.53 | 28.19 ± 6.66 | .48 |
| Mean gestational age at presentation | 33.17 ± 10.77 | 32.76 ± 11.02 | .19 |
| | **N (%)** | **N (%)** | |
| Age category | | | .77 |
| <20 | 412 (13.1) | 257 (13.8) | |
| 20-34 | 2158 (68.5) | 1254 (67.1) | |
| 35-39 | 434 (13.7) | 263 (14.1) | |
| ≥40 | 147 (4.7) | 94 (5.0) | |
| Ethnicity/Race | | | |
| Ethnicity | | | .41 |
| Hispanic or Latino | 635 (20.2) | 390 (20.9) | |
| Not Hispanic or Latino | 2452 (79.8) | 1478 (79.1) | |
| Race | | | .91 |
| American Indian or Alaska Native | 4 (0.1) | 4 (0.2) | |
| Asian | 50 (1.6) | 31 (1.7) | |
| Black or African American | 2297 (72.9) | 1342 (71.8) | |
| Hispanic | 610 (19.4) | 379 (20.3) | |
| White or Caucasian | 94 (3.0) | 63 (3.4) | |
| Multiracial | 57 (1.8) | 28 (1.5) | |
| Other | 74 (0.4) | 30 (0.3) | |
| Missing | 27 (0.9) | 15 (0.8) | |
| Parity | | | .93 |
| 0 | 213 (6.8) | 121 (6.5) | |
| 1 | 733 (23.3) | 435 (23.3) | |

| | | | |
|---|---|---|---|
| ≥2 | 2205 (70.0) | 312 (70.2) | |
| Insurance | | | .12 |
| Private | 432 (13.7) | 281 (15.0) | |
| Public | 2533 (80.4) | 1452 (77.8) | |
| Self-pay | 4 (0.1) | 2 (0.1) | |
| Missing | 182 (5.8) | 133 (7.1) | |
| | **Median (IQR)** | **Median (IQR)** | |
| Median Leonard comorbidity score | 11 (0-38) | 11 (0-38) | .55 |
| Median non-transfusion-associated Leonard comorbidity score | 6 (0-22) | 6 (0-21) | .53 |

SD: standard deviation
IQR: interquartile range
HB: House Bill
p-values are two-tailed

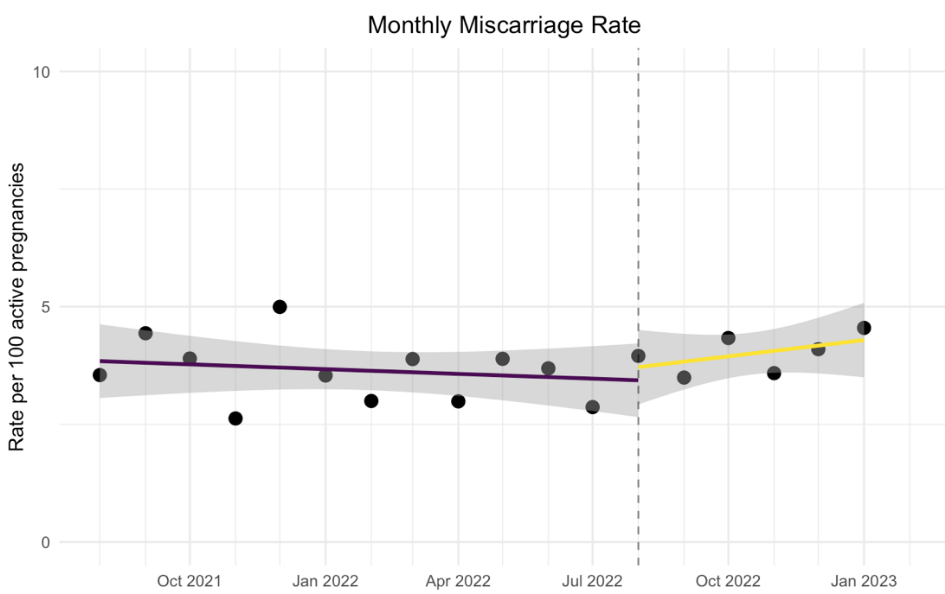
The rate of miscarriage diagnosis per 100 pregnancy-months was approximately constant between pre- and post-enactment periods (3.61 vs. 3.98 per 100 pregnancy-months; RR 1.10; 95% CI 0.77, 1.56) (Table 2 and Figure 1). The rate of early pregnancy complication demonstrated an increasing trend representative of a level change between periods (3.14 vs. 3.53 per 100 active pregnancy-months; RR 1.28, 95% CI 0.86, 1.91). The rate per 100 pregnancy-months of pregnancy complication at any gestational age displayed an increasing trend over time indicative of a slope change between periods (5.68 vs. 6.24 per 100 active pregnancy-months; RR 1.05, 95% CI 0.98, 1.12).

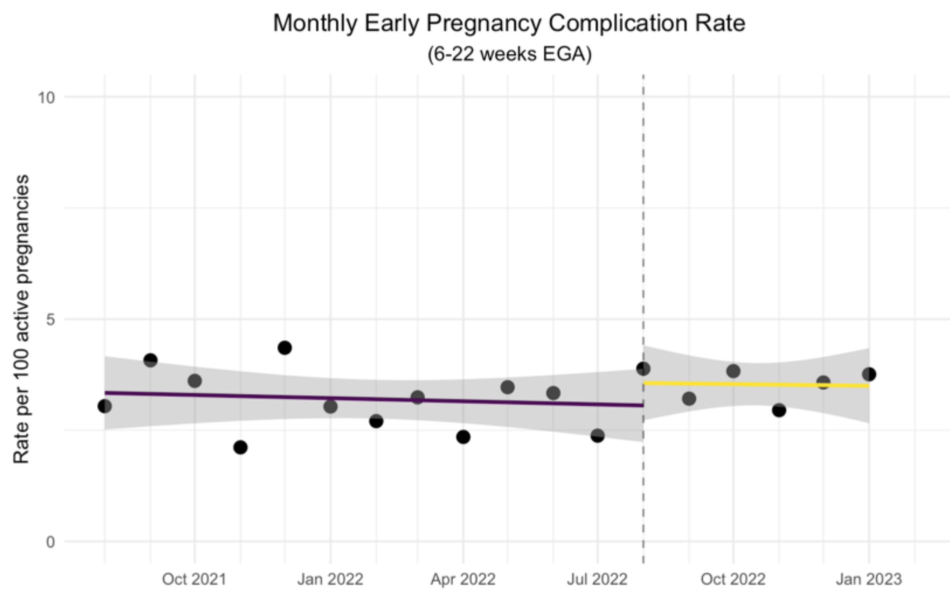
**Table 2**.
Rates of Pregnancy-Related Morbidity Outcomes Among Pregnancies Before and After Enactment of HB481

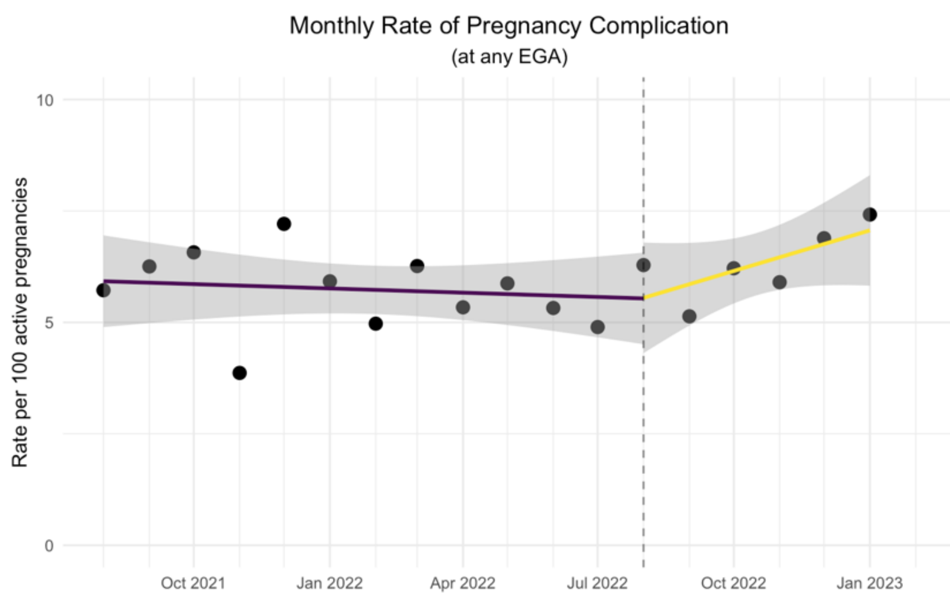
| | Before | | | After | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Outcomes/ pregnancy-months** | **Rate per 100 pregnancy-months** | **(95% CI)** | **Outcomes/ pregnancy-months** | **Rate per 100 pregnancy-months** | **(95% CI)** | **Rate ratio (95% CI)** | **p-value** |
| **Miscarriage diagnosis** | 604/16712 | 3.61 | (3.34, 3.91) | 303/7614 | 3.98 | (3.56, 4.44) | 1.10 (0.77, 1.56)‡ | 0.6 |
| **Early pregnancy complication** (6-22 wk EGA) | 525/16712 | 3.14 | (2.89, 3.42) | 269/7614 | 3.53 | (3.14, 3.97) | 1.28 (0.86, 1.91)‡ | 0.2 |
| **Pregnancy complication** (any EGA) | 950/16712 | 5.68 | (5.34, 6.05) | 475/7614 | 6.24 | (5.72, 6.80) | 1.05 (0.98, 1.12)♦ | 0.2 |

* A composite variable defined as:
**A composite variable defined as:
EGA: estimated gestational age
CI: confidence interval
HB: House Bill
‡ Rate ratio for the trend level change between periods
♦ Rate ratio for the trend slope change over time

**Figure 1**.
Scatterplots showing monthly variation in rates of morbidity-related pregnancy outcomes at Grady Memorial Hospital before HB481 went into effect (between August 1, 2021 and July 31, 2022) and after its implementation (between August 1, 2022, and January 31, 2023). *Circles represent observed monthly rate and solid line represents predicted rates.






## Discussion

Our study examined the impact of Georgia's HB481 on key indicators of pregnancy-related morbidity in a predominantly publicly insured, Black and Latinx/Hispanic population. With more pregnancies expected to be carried to term, there is concern that the attendant risks of pregnancy-related morbidity and mortality will further increase.[3] The results of our interrupted time series analysis suggest an increasing trend in the rate of early pregnancy complications and pregnancy complications at any gestational age in our study population after Georgia's HB481 went into effect in July 2022. These increases occur in a population with a high baseline complication rate.[26] No meaningful trend was observed in the rate of miscarriage diagnosis in our study population within the timeframe evaluated.

Previous literature has highlighted the adverse impacts of restrictive abortion legislation on obstetric complications in the peri-viable period as well as documented the inequities of abortion bans across racial, economic, and educational status.[15,21,30] Additionally, research conducted pre-Dobbs in anticipation of the ruling predicted increased maternal and neonatal morbidity in abortion-restricted settings as compared to protected settings.[2,10,24] Our study builds on existing knowledge through rigorous evaluation of pregnancy-related morbidity outcomes at a safety net hospital in Atlanta to characterize the impacts of Georgia's 6-week abortion ban. The unique contribution of this study is our examination of clinical outcomes among the population of all pregnancies at our hospital, adding to the existing work evaluating demographic patterns in abortion access or morbidity in pregnancies with indications for delivery on the threshold of viability.

Not everyone who might have received an abortion in the absence of abortion restrictions is now able to obtain one, and these effects on both abortion and birth rates are inequitably distributed. National data suggests that fertility rates are rising at a 2.3% higher rate in states where abortion is restricted as compared to protected states. This amounts to an estimated 32,000 additional births in these states per year as compared to states where abortion remains protected.[12] More specifically, researchers in Texas showed that approximately 10,000 additional births occurred over a 9-month period shortly after the enactment of their 6-week ban.[31] These effects are not distributed equally and were shown to be higher in people aged 20-24 and people of color, groups of people highly represented in our study.[12]

The Society for Family Planning's #WeCount project, which tracks clinician-provided abortions within the formal healthcare system, found that while the number of abortions has remained constant nationally since April 2022, the state of Georgia has seen one of the greatest magnitudes of decrease in abortions provided.[11] This is in line with previous work predicting that only 11.6% of abortions performed in Georgia would be legal under HB481.[2] With abortions in the formal healthcare setting being greatly restricted, self-managed medication abortion in the US has shifted from a more marginal to mainstream role and a significant source of abortion access in Georgia and throughout a post-Roe U.S.[11,32] Indeed, in the 6-month period immediately following the Dobbs decision, one study showed an estimated 26,055 additional self-managed medication abortions occurred as compared to what would have been expected pre-Dobbs.[32]

Those self-managing may experience barriers to accessing postabortion care in the formal healthcare setting, especially in states with restrictions in place.[33] Clinicians will increasingly see patients who are presenting to care after a self-managed abortion. We anticipated that, with an increased reliance on self-managed abortion, some patients may present to our hospital for post-abortion care after an abortion managed outside of the formal healthcare space. We attempted to evaluate this using data from our health system by examining rates of miscarriage-associated diagnosis. Miscarriage diagnosis is not a direct measure of increase in self-managed abortion, though is an outcome available in EHR data that can serve as a crude approximator. Importantly, miscarriage may be expected to increase not only in the setting of increased reliance on self-managed abortion, but additionally if more pregnancies are being carried to term. For these reasons, it will remain important to track miscarriage data as abortion restrictions remain in effect.

This work highlights the impacts of a six week abortion ban on a community likely to be most disproportionately impacted by its effects due to structural economic and racialized vulnerabilities.[2,16] Our results from the six months after implementation of Georgia's ban suggest that key indicators of maternal morbidity are likely to increase as the law remains in effect and access to full-spectrum pregnancy care is prohibited. Our study is strengthened by the use of interrupted time series analysis rather than a pre/post study design. This quasi-experimental study design is useful in evaluating the effects of a time-bound intervention (i.e., policy implementation) over time by limiting selection bias and confounding factors between the two populations.[27,34,35] In conducting this study, we show this methodology to be a robust approach to evaluating the impact of abortion legislation across context and over time as restrictive abortion legislation remains in effect.

**Limitations:**

These results must be interpreted within the context of our study's limitations. As this is a single site study, our findings may not be generalizable to the wider population of Georgia or to other policy contexts.

The six-month window of inclusion in our study after HB481 went into effect does not span the 40-week length of an average pregnancy, a shortcoming of this study that may limit the applicability of our results. Six months may not be a long enough window to observe the hypothesized changes. Further, a large proportion of pregnancies included in this study bridged the period of enactment (1,265/3,754), having been active in both the pre- and post-periods. In this work, we presented outcomes in terms of pregnancy-months as our denominator, a unit that allowed for us to ensure the integrity of our data but is difficult to interpret in the context of clinical practice.

In using an interrupted time series study design to measure policy impact, there remains the possibility of unmeasured confounders or coexisting interventions not considered. For example, it is possible that, in anticipation of changing abortion laws in the months leading up to the Dobbs decision and enactment of HB 481, people exhibit changed attitudes and behaviors toward pregnancy. Additionally, in recent years, widespread attention has been called to Georgia's unacceptably high rate of maternal morbidity and mortality.[36,37] With this awareness has come increased pressure on the Georgia legislature to take action toward improving pregnancy outcomes, especially among birthing people who are Black, brown, and low-income. There remains the possibility that adverse pregnancy outcomes stemming from HB481's implementation are co-occurring with improvements to pregnancy and postpartum care resulting from interventions the state has implemented – for example, expansion of post-partum Medicaid benefits – in an effort to combat high rates of pregnancy-related morbidity and mortality.[38,39]

Examining the clinical impacts of restrictive abortion legislation is an area of research that must continue to be rigorously borne out in coming years. It remains possible that we failed to include key measure of impact, and we look to colleagues to expand on this work by identifying and examining those outcomes.

**Conclusions and future directions:**

Examining the clinical impacts of restrictive abortion legislation is an area of research that must continue to be rigorously borne out in the coming years. Our quasi-experimental study design has shown to be a robust method of evaluating the impacts of Georgia's HB481 on pregnancy outcomes over time. These results suggest that there are increasing trends in pregnancy complications, both those occurring between 6-22 weeks estimated gestational age and throughout all of pregnancy. Our study also suggests the need for longitudinal evaluation of pregnancy-related morbidity. We plan to repeat this analysis with a longer timeframe of post-HB481 data to further track the trends presented here. These data suggest that as Georgia's HB481 remains in effect, it will continue to pose a direct threat to safe pregnancy in a population of people already at high risk for complications.

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# Supplemental Materials

## Supplemental Methods

**Table 1**. ICD codes for calculation of Leonard Comorbidity Score, using a validated, site-specific index

| Comorbidity Diagnosis Group | ICD-10-CM Codes |
|---|---|
| 01: Gestational diabetes mellitus | O24.4x |
| 02: HIV/AIDS | O98.7x, B20.x |
| 03: Preexisting diabetes mellitus | E08.x-E13.x, O24.0x, O24.1x, O24.3x, O24.8x, O24.9x, Z79.4x |
| 04: Previous cesarean birth | O34.21x |
| 05: Pulmonary hypertension | I27.0x, I27.2x |
| 06: Twin/multiple pregnancy | O30.x-O31.x, Z37.2x-Z37.7x |
| 07: Asthma (adjusted) | O99.5x, J45.x |
| 08: Bleeding disorder, preexisting | D66.x-D69.x |
| 09: Obesity (adjusted)* | E66.0x-E66.2x, E66.8x-E66.9x, O99.21x, Z68.3x-Z68.4x |
| 10: Cardiac disease, preexisting | I05.x-I09.x, I11.x-I13.x, I15.x, I16.x, I20.x, I25.x, I27.8x, I30.x-I41.x, I44.x-I49.x, I50.22, I50.23, I50.32, I50.33, I50.42, I50.43, I50.812, I50.813, O99.41x, O99.42x, Q20.x-Q24.x |
| 11: Chronic hypertension | O10.x, O11.x, I10.x |
| 12: Chronic renal disease | O26.83, I12.x, I13.x, N03.x-N05.x, N07.x, N08.x, N11.1x, N11.8x, N11.9x, N18x, N25.0x, N25.1x, N25.81x, N25.89x, N25.9x, N26.9x |
| 13: Connective tissue or autoimmune disease | M30.x-M36.x |
| 14: Placenta previa, complete or partial | O44.03, O44.13, O44.23, O44.33 |
| 15: Preeclampsia with severe features | O14.1x, O14.2x, O11.x |
| 16: Preeclampsia without severe features or gestational hypertension | O13.x, O14.0x, O14.9x |
| 17: Substance use disorder | F10.x-F19.x, O99.31x, O99.32x |

| | |
|---|---|
| 18: Anemia, preexisting | O99.01x, O99.02x, D50.x, D55.x, D56.x, D57.1x, D57.20x, D57.3x, D57.40x, D57.80x, D58.x, D59.x |
| 19: Bariatric surgery | O99.84x |
| 20: Gastrointestinal disease | K (entire block), O99.6x, O26.6x |
| 21: Major mental health disorder | O99.34x, F20.x-F39.x |
| 22: Neuromuscular disease | O99.35x, G40.x, G70.x |
| 23: Placental abruption | O45.x |
| 24: Placenta accreta spectrum | O43.2x |
| 25: Preterm birth | Z3A.20-Z3A.36 |
| 26: Thyrotoxicosis | E05.x |

*The definition of obesity used in our analysis differs from that defined by the authors of the Leonard Comorbidity Index in order to better reflect the study population. This adjusted obesity measure has been previously validated in Grady's obstetric population.

**Table 2**. Full list of cause-specific outcomes and complications explored:

All data definitions and ICD codes:

| **Data Element** | **Definition** |
|---|---|
| Delivery | Encounter for a delivery as defined by the Joint Commission |
| Abortion CPT encounter | Encounter with a CPT code: 59812-59857 |
| Abortion procedure encounter | Encounter with a ICD 10 procedure: 10A0xxx, 10D17ZZ, 10D18ZZ, 10D1xxx |
| | Encounter with a misoprostol order |
| Miscarriage diagnosis encounter | Encounter with a billed diagnosis code: O02.1, O03.X, O04.X, O07.X, O20.0, O26.951, O31.11X0, O31.12X0, O31.13X0, O31.21X0, O31.22X0, O31.23X0, Z33.2 |
| Outpatient obstetric encounter | Outpatient encounter with the OB/GYN department |
| Obstetric triage encounter | Encounter with a triage note |
| Corticosteroid administration | Betamethasone or dexamethasone appear on the MAR with a status of Given |
| Incomplete spontaneous abortion | Diagnosis Codes: O03.0x-O03.4x |
| Complete or unspecified spontaneous abortion | Diagnosis Codes: O03.5x-O03.9x |
| First trimester bleeding | Diagnosis Codes: O26.851 |

| | |
|---|---|
| Missed abortion | Diagnosis Codes: O02.1 |
| Continuing pregnancy after spontaneous abortion | Diagnosis Codes: O31.1x |
| Continuing pregnancy after intrauterine death | Diagnosis Codes: O31.2x |
| Preterm prelabor rupture of membranes | Diagnosis Codes: O42.00-O42.90, O42.01-O42.91 |
| Fever | Diagnosis Codes: O75.2, O86.4, R50.9 |
| Sepsis | Diagnosis Codes: O75.3, R65.2x, O03.07x-O03.97x, O85, O86.04, T80.211A, T81.4XXA, T81.44x, A40.x-A41.x, A32.7 |
| Shock | Diagnosis Codes: O75.1, R57.x, R65.21, T78.2XXA, T88.2XXA, T88.6XXA, T81.10XA, T81.11XA, T81.12XA, T81.19XA |
| Antepartum hemorrhage | Diagnosis Codes: O46.x |
| Preeclampsia with severe features | Diagnosis Codes: O11.x, O14.1x, O14.2x |
| Preeclampsia without severe features or gestational hypertension | Diagnosis Codes: O13.x, O14.0x, O14.9x |
| Fetal demise | Diagnosis Codes: O36.4x |
| Eclampsia | Diagnosis Codes: O15.x |
| Preterm labor | Diagnosis Codes: O60.x |
| Induction of labor | ICD10 Procedure Codes: 0U7C7DZ, 0U7C7ZZ, 10907ZC, 3E033VJ, 3E0DXGC, 3E0P3VZ, 3E0P7GC, 3E0P7VZ |
| Cesarean delivery | ICD10 Procedure Codes: 10D00Z0, 10D00Z1, 10D00Z2 |
| Cord prolapse | Diagnosis Codes: O69.0x |
| Hysterectomy | ICD10 Procedure Codes: 0UT90ZZ, 0UT94ZZ, 0UT97ZZ, 0UT98ZZ, 0UT9FZZ |
| Preterm delivery | Diagnosis Codes: O60.1x |
| Single live birth | Diagnosis Codes: Z37.0 |
| Single stillbirth | Diagnosis Codes: Z37.1 |
| Multiple live birth | Diagnosis Codes: Z37.2, Z37.5 |
| Multiple stillbirth | Diagnosis Codes: Z37.3, Z37.4, Z37.6, Z37.7 |
| Intrauterine death | Diagnosis Codes: O36.4x |
| Neonatal demise | Discharge Status is 'Expired' or diagnosis code of P95.x and LOS <= 1 day |
| NICU assessment | NICU Assessment completed |
| Vaginal delivery | Diagnosis Codes: Z38.00, Z38.30, Z38.61, Z38.63, Z38.65, Z38.68 |
| Cesarean delivery | Diagnosis Codes: Z38.01, Z38.31, Z38.62, Z38.64, Z38.66, Z38.69 |

| | |
|---|---|
| Chorioamnionitis | Diagnosis Codes: O41.12x |
| Infection of amniotic sac or membranes | Diagnosis Codes: O41.10x |
| Placentitis | Diagnosis Codes: O41.14x |
| Placental disorder | Diagnosis Codes: O43.x |
| Placental abruption | Diagnosis Codes: O45.x |
| Intrapartum hemorrhage | Diagnosis Codes: O67.x |
| ICU admission | Encounter has an ICD Admission timestamp |
| Blood transfusion | CDC SMM Definition |
| Dilation and curettage | ICD10 Procedure Codes: 10A07ZZ, 10A08ZZ, 10D17ZZ, 10D18ZZ |
| Maternal death | Discharge Status is 'Expired' |
| ED visit within 42 days | ED Visit within 42 days of discharge |
| Readmission within 42 days | Inpatient Admission within 42 days of discharge |
| SMM event | CDC SMM Definition - During event encounter |
| SMM readmission within 42 days | CDC SMM Definition - Within 42 days of discharge |
| Maternal death within 1 year | Inpatient Admission Discharge Status is 'Expired' within 365 days of discharge |