Maternal Stress, Compositional Change, and Infant Health after a State Sentencing Reform*

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Abstract

Due to the strong socioeconomic gradient in incarceration rates, scholars have identified mass incarceration as a potential channel behind continued discrepancies in health outcomes across socioeconomic groups. This paper leverages women's exposure to a state sentencing reform through their partner market to understand the relationship between incarceration rates and infant and maternal health. After the reform drastically increased incarceration rates, the average birth saw improvements in health outcomes. However, once maternal characteristics are accounted for the results are mixed: increases in the incidence of low birth weight births, hypertension, and the use of tobacco, but a decrease in preterm births. These results are consistent with both increased maternal stress and compositional change as mechanisms. A decomposition exercise shows both socioeconomic and biological factors are important contributors to the relationship between incarceration rates and infant and maternal health.

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1 Introduction

This paper uses a natural experiment to investigate the relationship between incarceration rates and infant and maternal health. Theory and previous work suggest two primary mechanisms through which increased incarceration rates could impact infant and maternal health. First, there is a potential causal effect: incarceration is a significant economic and social shock to family life. This shock could directly affect birth outcomes. Second, there is a compositional effect: incarceration has documented effects on fertility, marriage, and partner choice. By changing the composition of women who give birth, incarceration could indirectly affect aggregate infant and maternal health.

This study is motivated by historically significant levels of incarceration in the United States and by previous empirical work showing the importance of infant health for later life outcomes. Starting in the second half of the twentieth century, the United States witnessed an unparalleled expansion in the incarceration rate. By 2011, almost one percent of adults were under some form of correctional supervision (Glaze and Parks, 2011). This expansion was not distributed equally across society; incarceration is most common among poor, less-educated, and minority men (Lofstrom and Raphael, 2016). As a result, mass incarceration has the potential to exacerbate socioeconomic inequalities (Western, 2006).

There is a large literature establishing a positive association between health in-utero and at birth to better outcomes later in life. All else equal, healthy infants are healthier adults with greater educational attainment and better labor market outcomes.[1] Because of the strong socioeconomic gradient in incarceration rates, scholars have identified incarceration with as a potential channel to explain continued discrepancies in health outcomes across socioeconomic groups (Wildeman and Muller, 2012). Understanding the relationship between incarceration and infant health allows us to better comprehend the long-term effects of mass incarceration.

[1] See Almond et al. (2017) for a review of this literature focusing on in-utero and infant health shocks and Prinz et al. (2018) for a review on the importance of health across the life cycle.

It is difficult to identify the effect of incarceration on health outcomes. Incarceration rates are not randomly assigned to communities but are correlated with structural and economic factors, like poverty, that have independent effects on infant health. To mitigate the endogeneity inherent in incarceration, I focus on a policy-induced increase in incarceration due to a state sentencing reform. Enacted in October 1994, the North Carolina Structured Sentencing Act increased the incarceration rate for prime-age Black (white) men by 60 (40) percent by 1996. This increase was driven by changes in sentence length as entries into prison, the composition of crimes, and the overall crime rate remained stable.

I find evidence that community incarceration rates affect infant and maternal health through both of the channels identified above. When not taking the changes to maternal characteristics into account, I find evidence of improvements to aggregate infant and maternal health outcomes. This is consistent with a compositional shift towards women who are likely to have more resources and better access to care. However, when information on maternal characteristics in included in the regression, these improvements mostly evaporate. This difference is driven both by changes in the socioeconomic distribution of mothers, as proxied by marital status and education level, as well as biological factors, like the number of previous births. However, some positive effects remain even when controlling for maternal characteristics: women are more likely to report receiving any prenatal care and less likely to have a preterm birth.

This study contributes to this literature in several ways. First, I use a state sentencing reform as a natural experiment to understand the causal effect of increased incarceration rates on infant health. Second, by including infant health outcomes established by prior work to be strong predictors of later life outcomes, I expand our understanding of the intergenerational consequences of mass incarceration. Additionally, I consider how changes in the composition of mothers due to incarceration affects birth outcomes, a channel previous work has ignored.

The rest of the paper proceeds as follows: section 2 discusses the the potential mechanisms through which incarceration could affect infant and maternal health and previous empirical work related to this topic; section 3 discusses the source of variation in incarceration rates in more detail; section 4 describes the data used in the analysis; section 5 describes the plan of analysis; section 6 discusses the empirical results; finally, section 7 concludes.

2 Incarceration and infant health

Health at birth, often measured by an infant's birth weight, is linked to better educational, labor market, and health outcomes later in life (Prinz et al., 2018). There are two primary channels through which incarceration may affect infant and maternal health. First, increased levels of incarceration may have a causal effect on the health of women and their children. Second, incarceration rates may change the composition of women who give birth which in turn will affect aggregate measures of infant and maternal health. In this section, I describe these mechanisms in more detail and discuss previous related empirical work.

Incarceration is a large, direct shock to family life. About one-third of men and half of women in state correctional facilities report living with their families prior to imprisonment. Of those who lived with their families, about half of incarcerated parents report they were the primary source of income for their families before imprisonment (Glaze and Maruschak, 2010). The economic consequences from the loss of a primary earner could negatively affect infant health at birth (Dehajia and Lleres-Muney, 2004; Lindo, 2011). This effect persists even when the family member is released, as incarceration leads to lower rates of employment and lower reported income after release (Mueller-Smith, 2015).

Beyond these economic costs, Lee et al. (2014) show that having a family member, broadly defined, incarcerated is associated with increased likelihood of diabetes, hypertension, heart attack or stroke, and obesity for women. There is no effect for men with a family member incarcerated. Each of these health outcomes is a strong predictor of worse infant health (Schaefer-Graf et al., 2018; Mustafa et al., 2012; Leary et al., 2012; Leddy et al., 2008). Declines in health status could lead to worse health outcomes for any infants born to affected women.

Changes to women's partner and marriage markets also create an indirect causal channel through which incarceration may affect infant health. Men are much more likely to be incarcerated than women (Travis et al., 2014). Any policy that increases incarceration rates is going to have a disproportionate effect on men and skew the ratio of men to women in a community. The canonical Becker model of marriage and partner selection predicts that a decrease in the male-female ratio will lead to a decline in the number of marriages or partnerships that form and that women will have a decreased bargaining position in any relationships that do form. Charles and Luoh (2010), Mechoulan (2011), and O'Keefe (2019) find changes to marriage rates, fertility rates, and other women's outcomes consistent with the Becker model as a result of increased incarceration rates. The changes to assortative matching found in previous work are predictive of lower levels of relationship satisfaction. Additionally, incarceration-induced changes to the sex ratio will decrease women's bargaining power in a relationship, which may affect the distribution of household resources (Chiappori et al., 2002).

Both the direct and indirect channels discussed above are likely to increase stress which may affect health outcomes. Reductions in household income, the stigma of having a family member incarcerated, or lower quality relationships could each lead to increased levels of stress, which then compound on each other in a process called stress proliferation. Stress proliferation is the process through which stress experienced in one area of family life spills over to others. For example, the financial stress of having a partner incarcerated could lead a woman to work more, leaving her with less time for positive health behaviors. Poorer health then adds an additional level of stress to the family's life (Turney, 2014). Consistent with this, work in epidemiology finds that that mothers with partners who are incarcerated within the year prior to delivery are less likely to seek prenatal care in the first trimester (Dumont et al., 2014) and more likely to smoke during pregnancy (Dumont et al., 2015).

Maternal stress is a potential channel through which incarceration could causally affect infant health. Stress causes the body to release cortisol, known as the stress hormone, into the bloodstream. As hormones can pass across the placenta, the fetus will also be exposed. Anxiety can also impair uterine blood flow (Oberlander et al., 2008). Increased levels of maternal stress are associated with low birth weight, preterm delivery, pregnancy-induced hypertension and preeclampsia, and infants being born small for their gestational age (Oberlander et al., 2008). Severe maternal stress is also associated with increased incidence of congenital malformations in the Cranial Neural Crest (Hansen et al., 2000). As Black women more likely to experience higher levels psychosocial stress than non-Black women, these effects may contribute to racial disparities in maternal and infant health (Paul et al., 2008).

Together this suggests the causal effect of incarceration on infant health will be negative, as reductions in resources and increased maternal stress are both associated with worse health outcomes. Previous empirical work on the effects of incarceration on infant health is consistent with that prediction. Wildeman (2012) and Light and Marshall (2018) find increased state incarceration rates lead to increased rates of infant mortality. Given the racial disparities in incarceration rates across black and white men and the strong link he finds between infant mortality and the incarceration rate, Wildeman also tests if incarceration rates can explain the Black-white infant mortality gap. He finds up to 14.8% of the gap between Black and white infant mortality rates from 1990 to 2006 could be due to disparities in incarceration rates. This result demonstrates how incarceration could contribute to continued health disparities by socioeconomic status. Even if incarceration has an equally negatively effect on white and Black infants, incarceration could still increase racial inequalities because Black infants are so much more likely to be affected by incarceration. However, the direct effects of incarceration on health may not be all negative. Particularly if the incarcerated person was violent or engaged in domestic abuse before imprisonment, removal could be an improvement to the household environment (Wildeman, 2012).

In addition to the causal effect of incarceration on infant health, increased incarceration rates may change the composition of women who give birth. O'Keefe (2019) shows that young women respond to changes in partner markets caused by the NCSSA by delaying their fertility: fertility rates for young women declined, but there was no evidence of a corresponding decline to total completed fertility at later ages. Women who are induced to delay pregnancy may use that time to accumulate additional resources that can lead to improved health outcomes for them and their children. However, giving birth at older ages comes with increased health risks. These age-related risks may present at younger ages and have stronger negative effects for Black women (Geronimus, 1992). The effect of incarceration-driven compositional changes is ambiguous.

This study contributes to this literature in several ways. First, I use a state sentencing reform, described in the next section, as a natural experiment to understand the causal effect of increased incarceration rates on infant health. Second, I contribute to our understanding of the intergenerational consequences of mass incarceration by expanding the set of infant health variables, including other outcomes established by prior work as good predictors of later life outcomes, such as birth weight. Additionally, I consider how changes in the composition of mothers due to incarceration affects birth outcomes, a channel previous work has ignored.

3 Policy Background

State sentencing reforms are an integral contributor to the historic increase in incarceration rates in the United States. As a response to historically high crime rates in the in 1990s, almost every state passed legislation designed to increase the severity of criminal punishment, usually through laws that increased the time spent in prison per criminal offense. These reforms were a driving force behind increasing incarceration rates in the 1990s (Travis et al., 2014). The North Carolina Structured Sentencing Act (NCSSA) was typical of reforms pursued by states in this period.[2]

Enacted on October 1, 1994, the NCSSA was designed to be "tough on crime" by lengthening the amount of time spent in prison by convicted offenders. The law was also intended to move the state to a determinant sentencing system by making sentences more consistent across judges (Wright and Ellis, 1993). First, the NCSSA created a detailed sentencing grid based on offense type, severity, and previous criminal record. Unlike previous sentencing regimes, judges could not give sentences outside of these now narrower bands. This new sentencing grid also included a minimum sentence before which the offender could not be legally released. Importantly, this minimum was usually longer than the time offenders served under the previous framework. Second, the NCSSA replaced the previous "Good Time" system with an "Earned Time" system, which was less generous to inmates. Finally, the NCSSA abolished discretionary parole, eliminating the final option for shortening an inmate's sentence (Collins and Spencer, 1999). Figure 1 shows that the NCSSA double the average time served in prison for offenders in NC.

Figure 2 shows the effect of the NCSSA on the North Carolina prison system and includes the overall US incarceration rate for comparison. After years of stability, the North Carolina incarceration rate increased by close to one third between 1994 and 1995. Figure 3 displays the entry and exit dynamics that caused this quick increase and return to stability. While there was clearly year-to-year variation in entries into prison over this period, there was no trend break around the implementation of the NCSSA. Over this period, other characteristics about entrants (racial composition, age, felonies vs. misdemeanors, percent drug offenses, percent male) also remained stable (North Carolina Department of Public Safety, 1992-2000). The increase in the incarceration rate is not caused by a change in criminal behavior or related factors.

The increase in the prison population was caused by a decrease in exits, consistent with an increase in time served. As the prison system adjusted to the new sentence lengths,

[2] For a more thorough discussion of the NCSSA, including the sentencing policies that proceeded it, see O'Keefe (2019).

exits temporarily diverged from entrances. This dip in exits represents the period where inmates sentenced under the previous sentencing regime have already completed their relatively shorter sentenced, but inmates serving longer sentences due to the NCSSA were still waiting to be released. Since entries continue throughout the period, this temporary decrease in the exit rate generates a permanent population increase. By the end of the 1990s, entrances and exits converged again and the North Carolina prison system entered a new steady state level of incarceration.

Although the incarceration rate increased for all groups after the enactment of the NCSSA, the increases for Black and white men occurred on different absolute scales. Figure 4 shows the incarceration rate for men ages 15 to 44 over the time period of study. For Black men the NCSSA resulted in an increase in the incarcerates fate of about two percentage points. For white men, the increase is less than one half of a percent.

The North Carolina incarceration rate drastically increased between 1994 and 1995 as a direct result of inmates serving longer sentences in accordance with the sentencing guidelines provided by the NCSSA. This provides a natural experiment to test the effect of increased incarceration rates on a variety of outcomes, including infant and maternal health.

4 Data

I combine data from a variety of sources to estimate the effect of an increase in sentencing severity on infant and maternal health. First, I will detail the incarceration measures I use. Then, I will describe the outcomes I examine and their sources.

4.1 Incarceration data

Incarceration data are from the North Carolina Department of Public Safety (DPS). To create a measure of incarceration by age, race, and commuting zone, I use public offender information from the universe of convictions in North Carolina. These data are available beginning in 1972. This database includes information on the type and length of sentence, as well as offender characteristics, such as date of birth, race, sex, and the county of conviction.

I restrict the sample to white and black men ages 15 to 44.[3] I observe when the offender began his sentence and can count the number of men within an age and race group who were in prison from each county over the course of a calendar year. I follow the procedure for calculating the prison population used by DPS. An individual is counted in prison in the first (second) half of the year if his entry date is before June 30 (December 31) and his exit date is after. I then use the offender characteristics to calculate the population by age, race, and geographic groups.

To create an incarceration rate, I divide the prison population by the same age and race female population, using population data from the Surveillance, Epidemiology, and End Results Program (SEER). I use the female population for two reasons. First, since an important mechanism through which incarceration affects infant and maternal health is by skewing the sex ratio, the number of men incarcerated per woman more directly captures this than the traditional incarceration rate. Second, this reduces potential measurement error arising from how incarcerated persons are counted in population data. Incarcerated people are counted in the population of the county in which they are incarcerated, not the county they lived in before incarceration. This will artificially inflate the incarceration rate in areas where many incarcerated men come from and artificially reduce it in areas with larger prisons. Women are incarcerated at a much lower rate, so any measurement error from this mismeasurement is smaller.

4.2 Infant and maternal health data

Infant and maternal health outcomes are from the North Carolina Detailed Birth Database. These files contain information derived from birth certificates for the universe of births occurring in North Carolina between 1990 and 2000. I limit my sample to women ages 15

[3] I observe too few men of other races to create consistent series for those groups.

to 44 at the time of the birth who reside in North Carolina. I only include black and white mothers in the sample, who make up 96.8% percent of mothers in North Carolina from 1990 to 2000. These data include extensive information on the birth and on the mother, including her age, race, and county of residence. Most records include information on the completed weeks of gestation; in those cases, I estimate the time of conception by taking the date of birth minus the number of weeks reported. When that information is missing, I impute the time of conception as occurring nine months before the birth.

For infants, I examine the incidence of low birth weight and very low birth weight. Infants are considered low birth weight if they weigh less than 2500 grams at birth. The threshold for very low birth weight is 1500 grams. I also examine if the baby was born prematurely. A pre-term birth is defined as a birth occurring before 37 weeks of gestation (US Institute of Medicine, 2007).

These data also include information on maternal behavior and health. I examine if the mother received any prenatal care during the pregnancy, as well as if she reported the use of tobacco or alcohol during the pregnancy. Alcohol and tobacco use have well-known negative effects on infant outcomes (Almond et al., 2017), and in particular, increased tobacco use has been associated with partner incarceration in previous work. Finally, I examine if the birth certificate reports the presence of either pregnancy-associated hypertension or eclampsia. Both conditions are associated with high blood pressure, possibly consistent with a stress response (Almond et al., 2012).

To take advantage of the rich data on the birth certificate, I also construct three summary indices according to the procedure from Anderson (2008). I begin by recoding variables so that a positive or negative change leads to the same normative conclusion. For example in the case of the infant health index, a positive direction always indicates a healthier infant. I then normalize the outcomes and create an index variable that is the weighted average of the normalized outcomes. Instead of combining the outcomes in an ad hoc way, the outcomes are weighed by the inverse of the covariance matrix of the transformed outcomes. This will down weight outcomes that often occur together and put more emphasis on outcomes that contribute additional explanatory power.

I create two of these indices. The first includes a variety of measures designed to capture the underlying health status of the infant: low birth weight, very low birth weight, high birth weight, conditions of the newborn noted on the birth certificate in North Carolina (anemia, birth injury, fetal alcohol syndrome, respiratory distress syndrome, Meconium aspiration syndrome, assisted ventilation, or seizures), small for gestational age, whether the infant needed to be transferred to another facility for specialized care, and the one and five minute APGAR scores. A positive score indicates a healthier infant.

The second index focus on maternal health. One combines several of the outcomes associated with maternal stress, discussed in section 2. Specifically, I include whether the birth certificate reports eclampsia, hypertension, diabetes, herpes, too little or too much weight gain, or if the mother needed to transferred to another facility for additional health treatment. A positive score indicates a healthier woman.

All of these are associated with infant and maternal health, but many of these outcomes are not very common. If I tested for each individually, I would be testing for too many hypotheses. By combining them into an index I can include additional information in the analysis. However, the magnitude of the index is not informative. In order to be able to interpret the magnitude of my results and compare them to prior work, I also look at a subset of infant and maternal health outcomes directly, as discussed in the next section.

Finally, I examine the incidence of infant and fetal deaths. Infant mortality data are from the North Carolina Consolidated Birth Files. These data link each infant death to the infant's birth record. These records include all the information on the mother and infant present in the birth files described above combined with information on the date and cause of death for infants who die before the reach one year of age.

Fetal death data come from the North Carolina Fetals Stat Files. North Carolina defines a fetal death as a spontaneous death occurring at 20 or more weeks of gestation. Similar to the infant mortality files, the fetal death files contain enough detail on the mother and conception time that the same procedure, described below in section 5, can be used to assign treatment intensity for all outcomes.

Summary statistics of the complete sample used for analysis for the full sample are displayed in table 1. Table 2 presents summary statistics by mother's race and shows important differences between black and white mothers. On average, black mothers are younger, less likely to be married, and less likely to have a college education. They also face partner markets with much higher rates of incarceration. The partner-market incarceration rate for black mothers is over six times higher than that of white women. Black infants are also more likely to experience a variety of negative birth outcomes, although the maternal health measures are more similar across the two groups.

The striking racial gaps in maternal mortality rates between white and black women have received increased attention from scholars and policy makers.[4] However, I am unable to include maternal mortality in the statistical analyses. While these data are available, the number of pregnancy-related deaths is too small for meaningful statistical analysis: 84 Black and white women ages 15 to 39 died from pregnancy-related causes between 1990 and 2000. While the numbers are small, racial disparities are still clear. Black women account for 58% of pregnancy-related deaths over that time period even though they make up around 25% of the population [5]

4.3 Additional data used for analysis

I also use information on crime rates and unemployment in my primary analyses to capture additional time varying factors that could infant and maternal health. Data on the crime rate, defined as the number of offenses known to police divided by the population are from the Federal Bureau of Investigation's (FBI) Uniform Crime Reporting (UCR) program. Data

[4]Huge Racial Disparities Found in Deaths Linked to Pregnancy (May 7, 2019), *New York Times*. Retrieved from http://nytimes.com.

[5]Authors' calculation using North Carolina State Center for Health Statistics (1989-2001) and National Cancer Institute (2016) data.

on unemployment are from the Bureau of Labor Statistics' (BLS) Local Area Unemployment Statistics.

5 Specification

In order to understand the relationship between incarceration rates and infant and maternal health, I use two primary specifications. The first looks at the relationship between the incarceration rate and aggregate health outcomes and the second incorporates demographic data in order to help understand how the direct and compositional effects of incarceration are affecting birth outcomes. Comparing these two specifications is similar in spirit to recent work by Ma and Simon (2020) who examine how changes in access to contraception as a result of the Affordable Care Act affects infant health and maternal composition.

The first equation is:

$$Y_{arct} = \alpha + \beta IR_{arct} + \lambda_{cr} + \gamma_{tr} + \mathbb{X}_{ct}\psi + \varepsilon_{arct} \tag{1}$$

Where a is the woman's age, r is her race, c is her commuting zone, and t is the time of conception. When run on the individual level, Y_{arct} is one of the two indices discussed in section 4 or the individual incidence of a single measure of infant or maternal health (low birth weight, preterm birth, pregnancy-related hypertension, eclampsia, use of tobacco, use of alcohol, receipt of prenatal care, and whether or not prenatal care started in the first trimester). In order to incorporate data on infant and fetal death, I also run the regression on cell level outcomes. Cells are defined by age, race, commuting zone, mother's education in four categories (less than 12 years, exactly 12 years, between 13 and 15 years, and 16 or more years of education), marital status, and parity (first, second, third, and fourth or later birth). The outcomes are the number of fetal deaths per live birth and the number of infant deaths per live birth. These regressions are weighted by the number of births in the cell.

A primary mechanism through which incarceration may affect infant health is through changing the availability of women's fertility partners. With this in mind, I assign incarceration rates (IR_{arct}) according to her partner market at the time of conception. Consistent with previous work, I define a woman's partner market to be men of her same race, in the same geographic area, who are her age or slightly older. Charles and Luoh (2010) show that marriages conform to this pattern in recent census years. Analyses using North Carolina natality data confirm this pattern for births as well (O'Keefe, 2019).

The geographic area used in these analyses is the commuting zone (CZ). CZs are units of analysis designed to reflect observed patterns of economic and social activity. Relationships are not bound by the nearest county line, but often form across these boundaries. By using the CZ as the geographic level in my analyses, I can better account for spillovers between neighboring counties. Additionally, aggregating from counties to CZs causes the effective number of observations within my clusters will be more similar across clusters, improving the quality of inference (MacKinnon and Webb, 2017).

λ_{cr} is a fixed effect to capture time unvarying characteristics of a CZ. γ_{cr} is a year fixed effect. In pooled models, these effects are race-specific. All analyses allow standard errors to be correlated within commuting zones overtime.

I use this model to get a bound on the overall effect on infant and maternal health without taking into account changes in composition. This specification is similar to the state-level models in Wildeman (2012), who also examines incarceration, or Dehajia and Lleres-Muney (2004), who look at the effect of unemployment. Both studies also include a variety of state level covariates in their regressions to account for non-fixed state characteristics that may influence the outcome of interest. While many of the variables they include are not available at the sub-state level, I do include the crime rate and the unemployment rate in all regressions (represented by $\mathbb{X}_{ct}$).

The second specification, similar to Currie et al. (2009) includes additional fixed effects to take into account maternal demographics:

$$Y_{arcmept} = \alpha + \beta IR_{arct} + \lambda_{cr} + \gamma_{tr} + \mathbb{D}_{arcmept}\theta + \mathbb{X}_{ct}\psi + \varepsilon_{arcmept} \tag{2}$$

Where a is the woman's age, r is her race, c is her CZ, m is her marital status, e is her education level, p is the parity of the birth, and t is the time of conception. $\mathbb{D}_{arcmept}$ is a vector of demographics: age (15-24, 25-34, 35+), race (white or Black), Hispanic ethnicity, education level, marital status, and parity. The other parts of the specification remain the same.

In order to better understand how maternal characteristics influence the relationship between incarceration rates and infant health, I employ the decomposition procedure from Gelbach (2016). This approach treats each of the additional regressors in equation 2 as an omitted variable from equation 1. Using a series of separate regressions to measure the relationship between each "omitted" variable (maternal characteristics) and the main variable of interest (incarceration rates), I can estimate each variable's contribution to the gap between equations 1 and 2. Unlike an approach where additional covariates are added one at a time, this result will not be dependent on the order of analysis.

This is especially important in cases where the additional covariates are correlated. For an example in this context, maternal education levels and marital status have a well documented relationship: women with higher levels of education are significantly more likely to be married when they give birth (Lundberg et al., 2016). If I were to add both marital status and education level as additional covariates in a series of regressions, the relative importance of the two factors would appear to depend on which characteristic I included first. This method avoids that issue. I perform the decomposition separately for Black and white mothers.

6 Results

6.1 Infant health

Figure 5 presents the results on infant health. For each outcome, the empty symbol reports the results of specification 1, the effect on aggregate infant health. The filled symbol reports the results of specification 2, which includes information from the birth certificate on demographic characteristics and socioeconomic status of mothers. The figure reports both pooled results as well as the results of race-specific regressions. For ease of interpretation, all incarceration rates have been scaled per 100. I find evidence that higher incarceration rates are associated with better infant health outcomes: a reduction in the incidence of low birthweight and infant mortality for both groups, and a reduction in the fetal death rate for white mothers. However, once I introduce information on maternal characteristics into the regression, the positive effects disappear and the relationship between incarceration and low birth weight switches direction. The point estimate for the pooled estimate implies that each additional man incarcerated per 100 women is associated with a 0.156 increase in the incidence of births under 2500 grams. When compared to the sample mean, this effect is small: around 1.8 percent.

The effects on fetal and infant deaths are also small and generally disappear once maternal characteristics are included in the analysis. Interestingly, these results are consistent with the results from Wildeman (2012) on infant mortality. There is an observed decrease in infant mortality for Black and white infants, but the point estimate for Black infants is about 10 times smaller in magnitude (-0.023 versus -0.201). This would be consistent with a widening infant mortality gap. Full results can be found in table form in table 3.

To better understand the results for low birth weight, figure 6 decomposes relative contributions of different maternal characteristics to the differences between the two specifications. Almost all the difference between the two specifications can be explained by the change in marital status and education levels of women giving birth. Perhaps surprisingly, the shift towards older mothers does not play a strong role here. For white mothers, the effect of age is both relatively small and statistically insignificant. For Black mothers, the shift in the age distribution by itself would lead to small increase in the incidence of low birth weight births, but this effect is completely dominated by the change in the socioeconomic status of mothers.

These results are consistent with both effects discussed in section 2. Compositional changes in who is giving birth leads to overall better health outcomes. When maternal characteristics are taken into account, the effects are potentially consistent with mothers having fewer resources or possibly more stress. Next, I turn to the results on maternal health outcomes and health behaviors to see if they can provide insight into the mechanisms driving these health effects.

6.2 Maternal stress and health behaviors

Figure 7 presents the results on incarceration and maternal stress. As with the infant health figure, for each outcome, the empty symbol reports the results of specification 1 (the effect on aggregate maternal health) and the filled symbol reports the results of specification 2 (including information from the birth certificate on demographic characteristics and socioeconomic status of mothers). Similar to the results for infant health, increased incarceration appears to be associated with improvements in health outcomes associated with maternal stress. However, this improvement seems to be driven by a change in the composition of women who give birth. Once information on maternal characteristics is included in the regression, the effects are attenuated and potentially switch direction. However, there is still evidence of a decrease in the incidence of preterm births. For white women only, there is evidence of an increase in the incidence of pregnancy associated hypertension. Full results are also available in table 4.

I repeat the decomposition exercise for preterm birth and pregnancy-related hypertension to help understand the mechanisms driving the difference between the two specifications.

These outcomes are especially important as they are two of the most common causes of infant and maternal mortality (US Institute of Medicine, 2007; Say et al., 2014). The results for preterm births are presented first, in figure 8. For infants born to white mothers, this decomposition looks similar to the one for low birth weight. The difference between the two specifications can be mostly explained by the shift towards more married and more educated women. However, for infants born to Black women, the story is more complicated. While the change in distribution of marital status and education levels does have an affect on the estimates, parity (the number of previous live births) is influencing the relationship in the opposite direction, which explains why the results from the two specifications are more similar for Black women.

Parity remains an important factor when decomposing the relative importance of maternal characteristics on the relationship between incarceration rates and pregnancy-related hypertension, particularly for white women. Previous work finds a decrease in the portion of first births for white women after the enactment of the NCSSA (O'Keefe, 2019). The effect is small: the portion of first births decreases by 0.6%.[6] However, even though that effect is small, the biological relationship between parity and gestational hypertensive disorders is strong and well established in the medical literature. The risk of gestational hypertension is significantly higher during the first pregnancy than subsequent pregnancies (Ness et al., 1993; Rurangirwa et al., 2012). Protective adaptations developed by the body during the first pregnancy, like the remodeling of maternal vascular structures related to the placenta, are a likely mechanism behind this relationship (Gaillard et al., 2014). Very similar results can be seen for eclampsia, another vascular complication of pregnancy, in figure 10. Together, these results imply that beyond the socioeconomic changes in the composition of mothers, women who give birth after incarceration rates increase are more likely to have had previous births. This creates a protective effect that leads to aggregate decreases in the incidence of these outcomes. However, once this change in the distribution of births is accounted for, the

[6]There is no statistically significant effect on parity for Black women, which may explain why parity is not as consistently important in these decompositions for that population.

effect is attenuated.

Information on maternal health behaviors may help further explain these pair of effects, presented in figure 7. As with the previous figures, for each outcome the empty symbol reports the results of specification 1 and the filled column reports the results of specification 2. There is evidence of a decrease in reported positive health behaviors, and this relationship is stronger when maternal characteristics are taken into account. Particularly in the case of tobacco use, women are much more likely to report having smoked cigarettes while pregnant as incarceration rates increase. Caution should be applied when interpreting the absolute magnitudes of these coefficients as use of tobacco and alcohol are known to be underreported on birth certificates (Dehajia and Lleres-Muney, 2004). However, the direction of the change is still informative. Both alcohol and tobacco use are associated with worse infant outcomes (Almond et al., 2017), so this change in behavior may explain the increase in the incidence of low birth weight births.

This result is consistent with prior work on incarceration and tobacco use discussed in section 2 (Dumont et al., 2015). There also appears to be an increase in the reported use of alcohol during pregnancy. Although the effect is not as strong, this could also be consistent with stress proliferation due to the direct effects of having a family member incarcerated or the indirect effects of having ended up in a lower quality relationship. However, the effect is more muddled when looking at the use of prenatal care. While the pooled effect and the effect for white women is attenuated when maternal characteristics is added to the regression, the effect for Black mothers remains constant and significant. Compared to the mean, this is effect size of just under 10 percent. This suggests that even beyond the observed changes in the compositions of mothers, there may be additional selection into who gives birth as incarceration rates rise as a result of the NCSSA.

Similar to the results for infant health, I observe improvements in aggregate maternal health: decreases in the incidence of preterm birth, pregnancy-related hypertension, and eclampsia. However, once maternal characteristics are taken into account, these results are attenuated (although not always completely). Unlike for low birth weight, where socioeconomic factors such as marriage and education were the most important driver of the the differences between the two specifications, socioeconomic factors and biological factors, especially parity, are important drivers of these patterns for maternal health. The observed effects on maternal health behaviors follows of similarly mixed pattern. While there is potential evidence of increases in maternal stress, even when characteristics are taken into account, there are also consistent improvements in prenatal care receipt for Black women.

6.3 Sensitivity

I employ a variety of alternative specifications to test the sensitivity of my results. A summary of these tests is visible in figure 13. In order to preserve readability, only the pooled estimates are reported in the figure. The symbols follow the same pattern of the previous figures: the empty symbol presents results from equation 1 and the filled symbol presents results from equation 2. For all outcomes, the first two dots reproduce the result presented in the main figures for comparison purposes (labeled "Main").

The second grouping, labeled "Trends" adds time trends to the regression. The first set adds a CZ-specific linear time trend and the second adds a cubic CZ-specific time trend. The pattern of results are consistent to the inclusion of these trends.

The variation I am using for identification is concentrated around the introduction of the NCSSA, in late October 1994. As discussed in section 3 and visible in figures 2 through 4 the most significant change in incarceration rates occurs in the middle of the decade. In order to make sure the results I observe are being driven by that policy induced change in incarceration rates, the third grouping (labeled "Time window") shortens the time window. While the primary regressions include year 1990 – 2000, these results shorten the included window to 1991 – 1999, 1992 – 1998, and 1993 – 1997 respectively. The results are very robust to this change, providing additional evidence that these results are being driven by the NCSSA.

The final group explores alternative replaces the incarceration rate per 100 men with the natural log of the women's partner market incarceration rate, assigned as described in section 5. Because the underlying variation is different the point estimates are also different. However, the general pattern of aggregate improvements in health outcomes attenuated by the inclusion or maternal characteristics remains.

7 Conclusion

In this study, I leverage a state sentencing reform (the NCSSA) as a natural experiment to investigate the link between incarceration and birth outcomes. I find both positive and negative effects on infant and maternal health. After the NCSSA, the average birth saw improvements in health outcomes for infants and mothers. However, these observed improvements are driven by changes in the composition of mothers. Once the change in maternal composition is taken into account, I observe an increase in the incidence of low birth weight births and pregnancy hypertension. I also document an increase in the portion of mothers using tobacco and alcohol during pregnancy. Both of these effects are consistent with increased maternal stress and stress proliferation. However, I also observe some health improvements, specifically a decline in preterm births. A series of decomposition exercises shows that both socioeconomic factors and biological factors are important for explaining how maternal characteristics affect the relationship between incarceration rates and health.

Together, these results point to two separate sets of mechanisms affecting the health of infants and mothers in different ways. First, there are mechanisms directly tied to incarceration, particularly those related to stress. Incarceration is a stressful event for families and either acute or chronic stress in mothers is linked to worse birth outcomes. The results for preterm births and hypertension for white women are most consistent with this mechanism. Second, incarceration also affects aggregate infant health by changing the pool of women who give birth. Prior work on the NCSSA shows many young women, particularly Black young women, delayed childbearing as a result of the reform. The women who continue to give birth after the incarceration-induced contraction of partner markets may be different in otherwise unobservable ways that lead to better aggregate outcomes for both infants and mothers.

Previous work has primarily found negative effects of incarceration on infant health, consistent with a direct mechanism. I also find evidence consistent with this mechanism. However, I also observe improvements in infant health consistent with another mechanism: incarceration changing the selection of which women become mothers. This study highlights the importance of changes in the composition of mothers. While changes in maternal circumstances and behavior are important detriments of community infant health, who has a baby (and who does not) are also important drivers of the effects.

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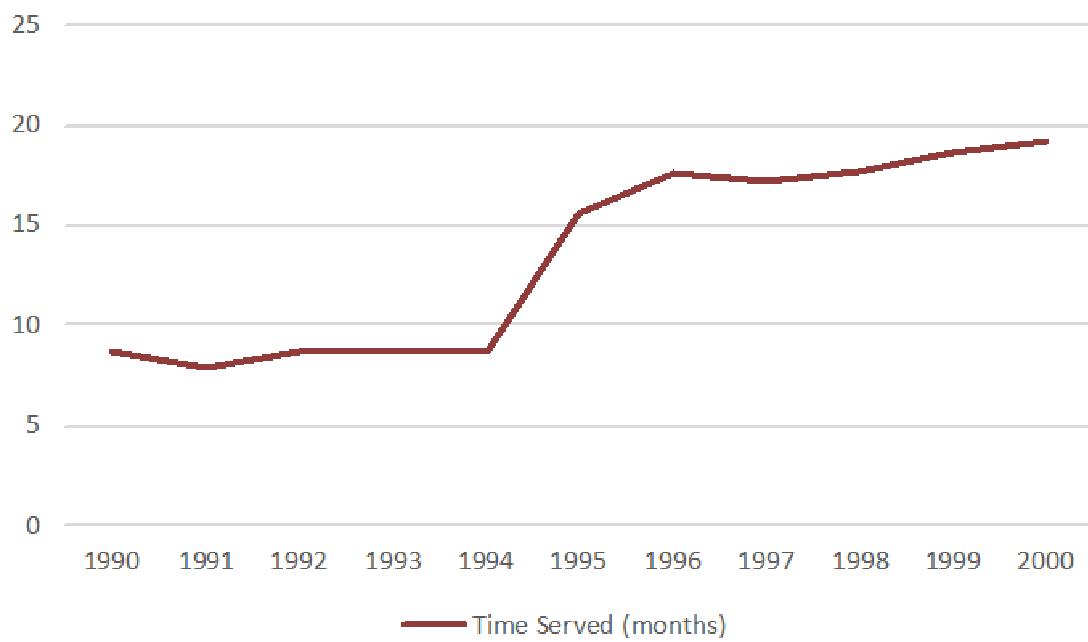
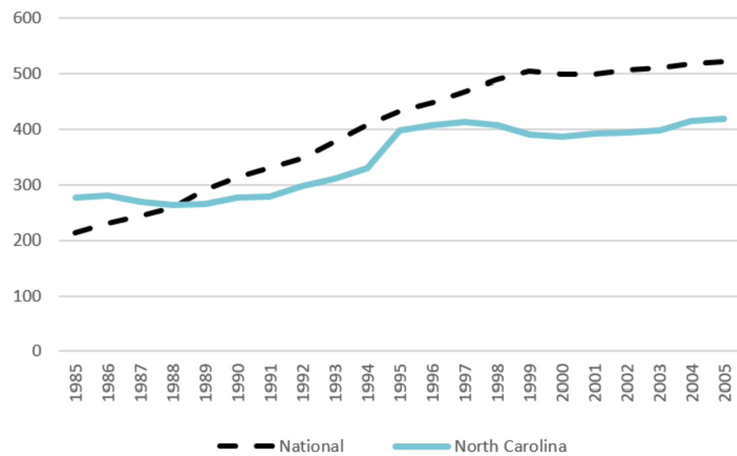
8 Figures

Figure 1: Average time served in months by year of entry for North Carolina prisoners, 1990 – 2000



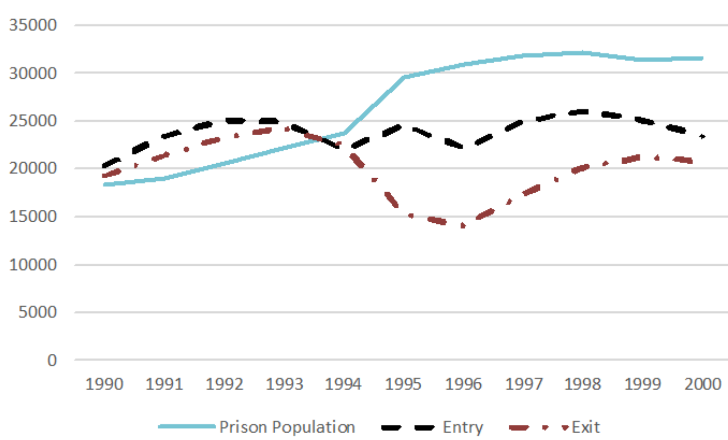
Source: North Carolina Department of Public Safety and author's calculations. Calculation of mean time served excludes prisoners serving life sentences.

Figure 2: Prisoners per 100,000 population, North Carolina and the United States, 1985 – 2005



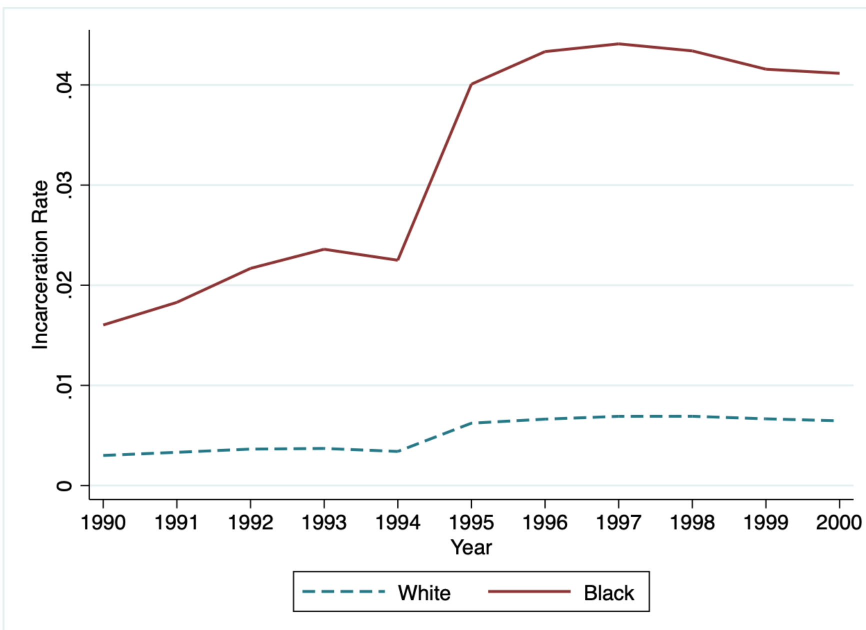
Source: Bureau of Justice Statistics, National Prisoner Statistics.

Figure 3: North Carolina prison entry, exit, and population, 1990 – 2000



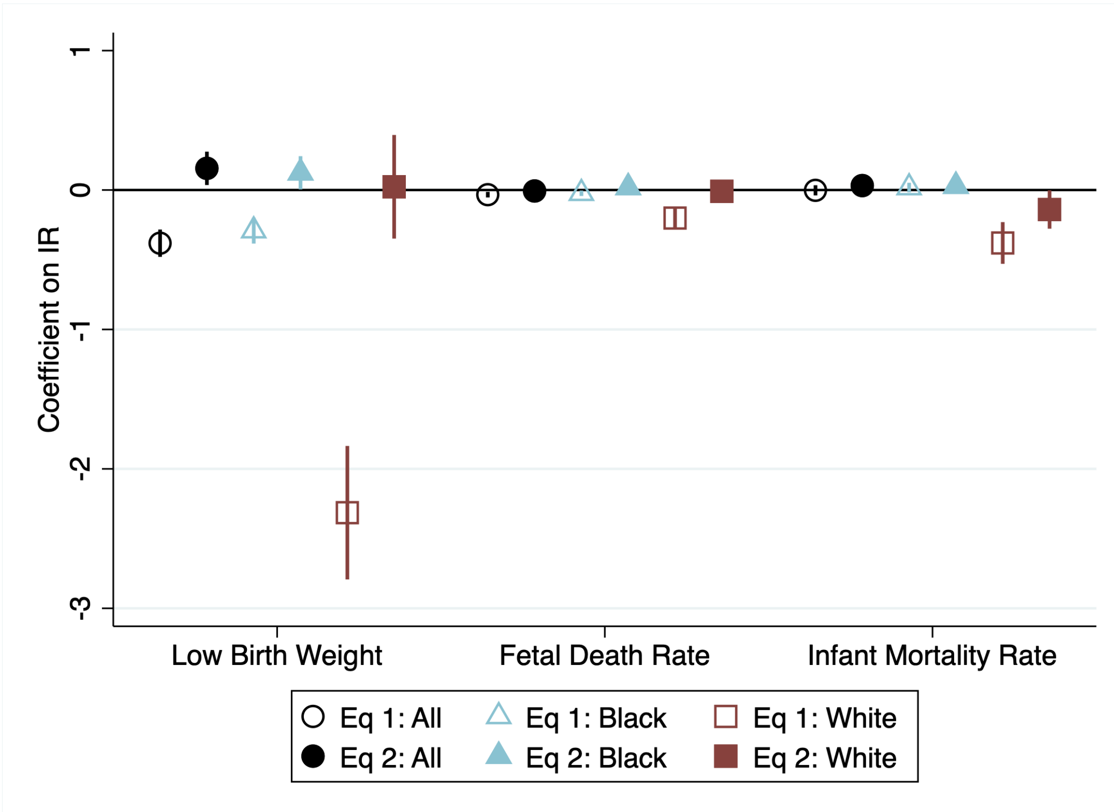
Source: North Carolina Department of Public Safety and author's calculations.

Figure 4: North Carolina adult male incarceration by race, 1990 – 2000



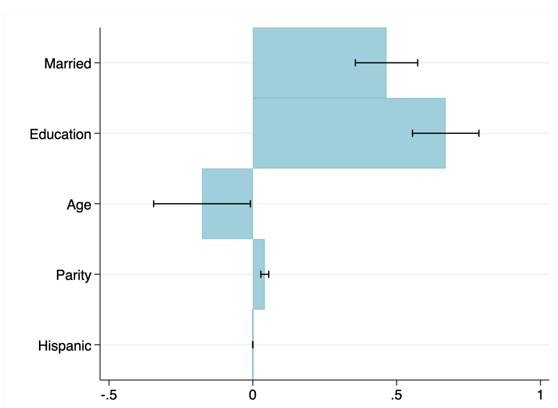
Includes men 15-44. Source: North Carolina Department of Public Safety and author's calculations.

Figure 5: Effects of incarceration rates on infant health

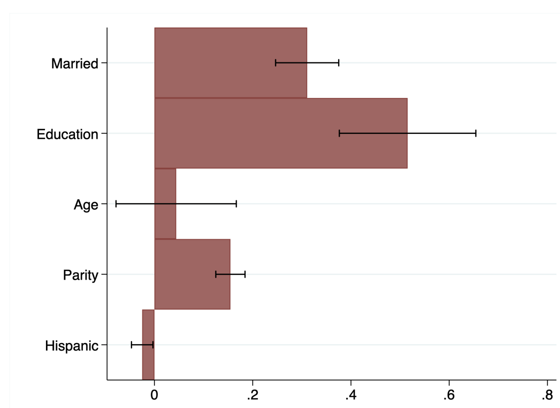


This table reports the results of regressing equations 1 and 2. Dependent variable indicated on horizontal axis. IMR and FDR regressions weighted by the number of births in the cell. Includes years 1990 – 2000. Vertical lines indicate 95% confidence interval. Standard errors clustered by CZ of residence.

Figure 6: Gelbach decomposition of maternal characteristics on the relationship between incarceration and low birth weight

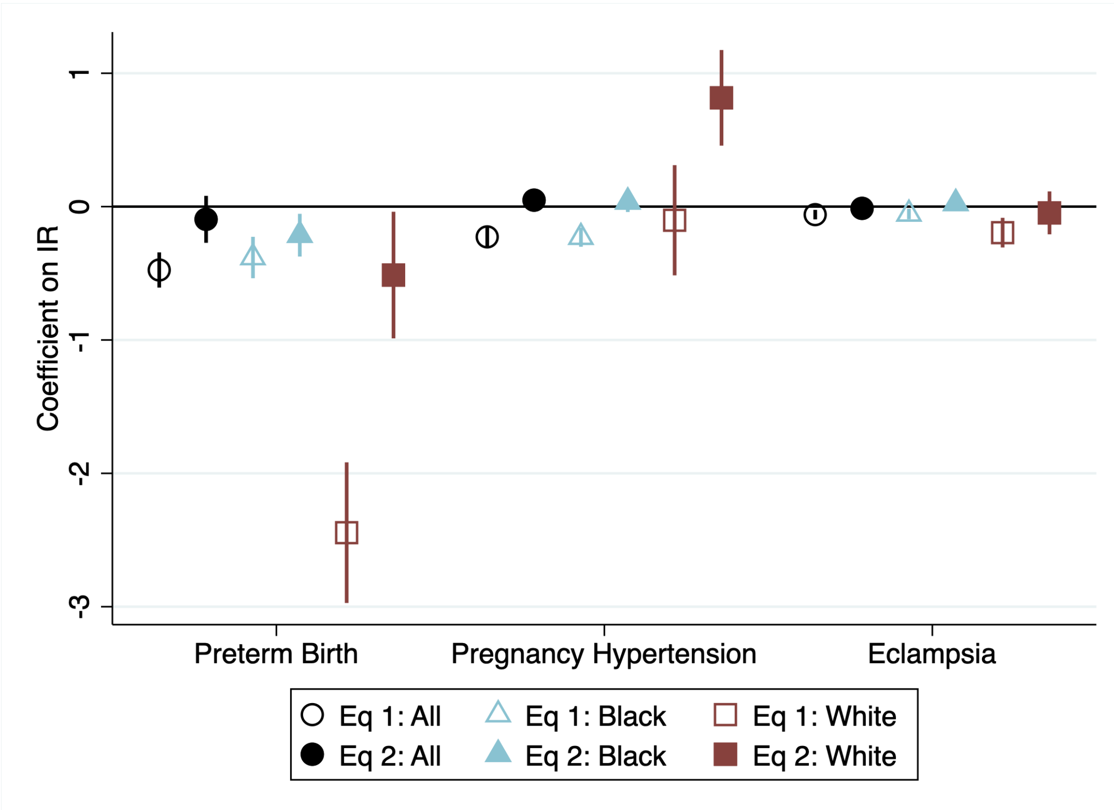


(a) Infants born to Black mothers



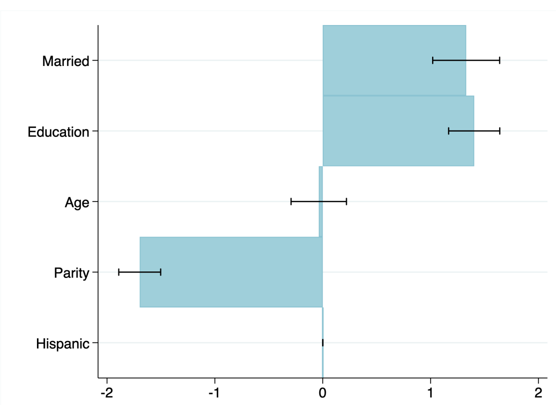
(b) Infants born to white mothers

Figure 7: Effects of incarceration rates on health conditions associated with maternal stress

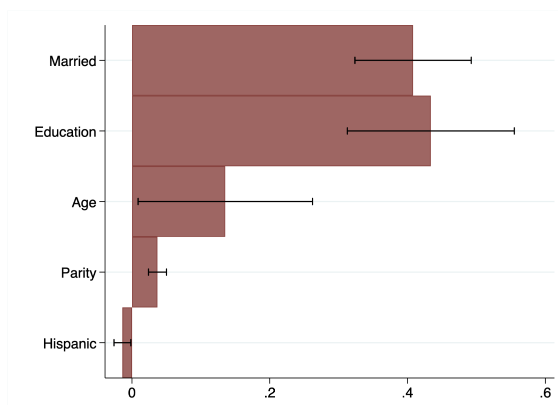


This table reports the results of regressing equations 1 and 2. Dependent variable indicated on horizontal axis. Includes years 1990 – 2000. Vertical lines indicate 95% confidence interval. Standard errors clustered by CZ of residence.

Figure 8: Gelbach decomposition of maternal characteristics on the relationship between incarceration and preterm birth

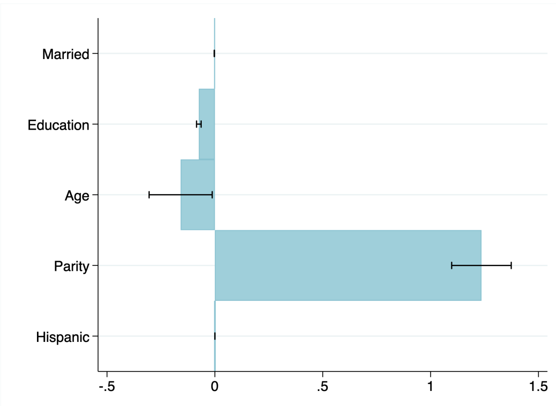


(a) Infants born to Black mothers

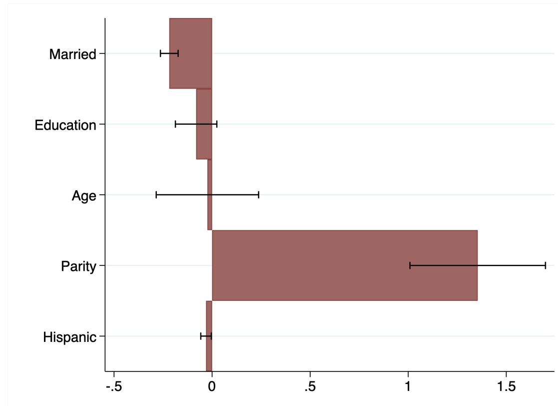


(b) Infants born to white mothers

Figure 9: Gelbach decomposition of maternal characteristics on the relationship between incarceration and pregnancy related hypertension

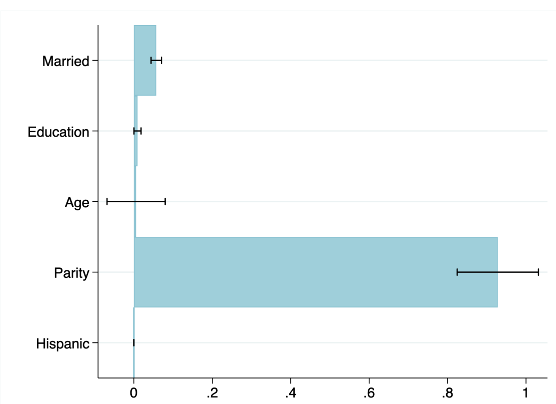


(a) Infants born to Black mothers

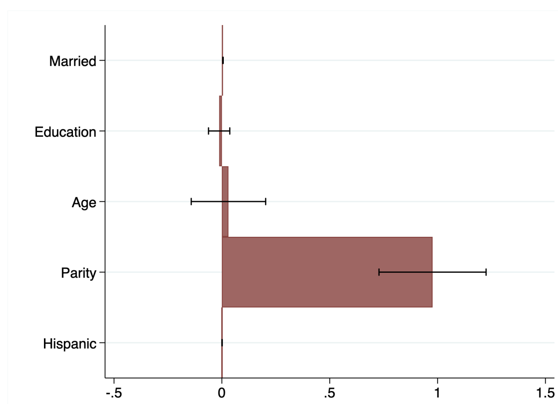


(b) Infants born to white mothers

Figure 10: Gelbach decomposition of maternal characteristics on the relationship between incarceration and eclampsia

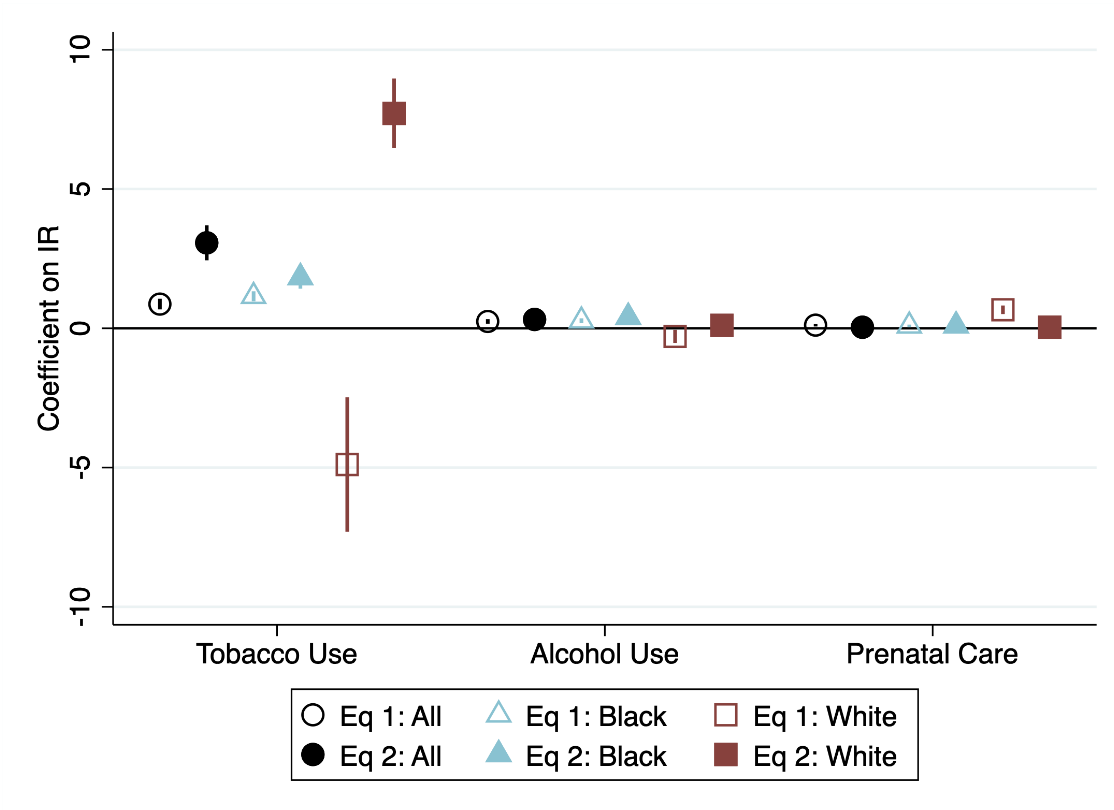


(a) Infants born to Black mothers



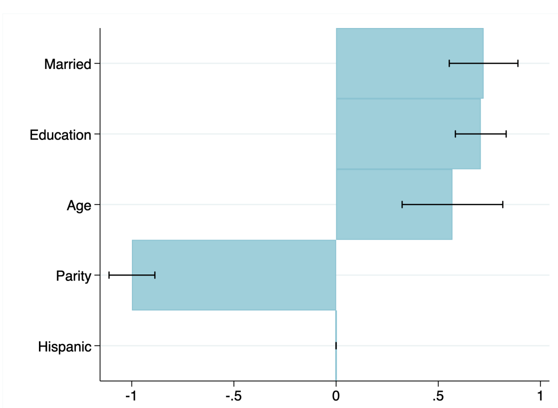
(b) Infants born to white mothers

Figure 11: Effects of incarceration rates on maternal health behaviors

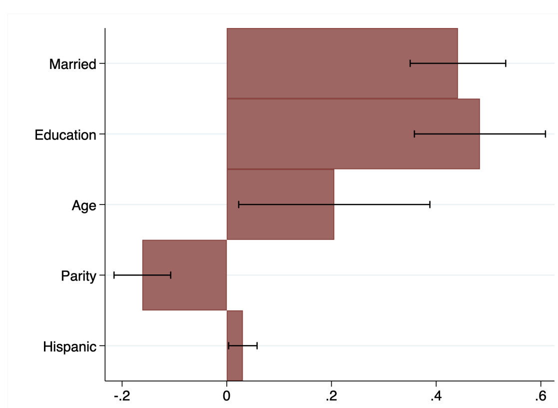


This table reports the results of regressing equations 1 and 2. Dependent variable indicated on horizontal axis. Includes years 1990 – 2000. Vertical lines indicate 95% confidence interval. Standard errors clustered by CZ of residence.

Figure 12: Gelbach decomposition of maternal characteristics on the relationship between incarceration and prenatal care

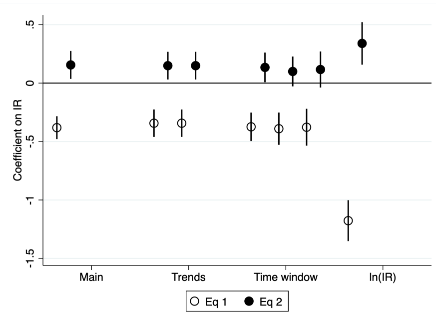


(a) Infants born to Black mothers

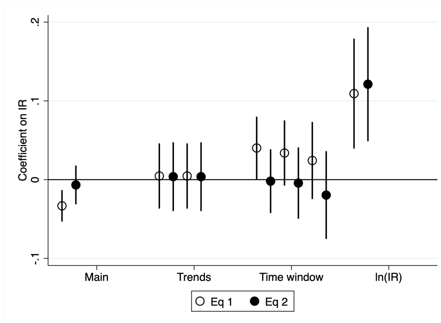


(b) Infants born to white mothers

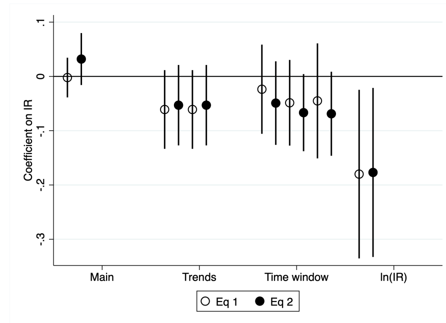
Figure 13: Sensitivity analysis



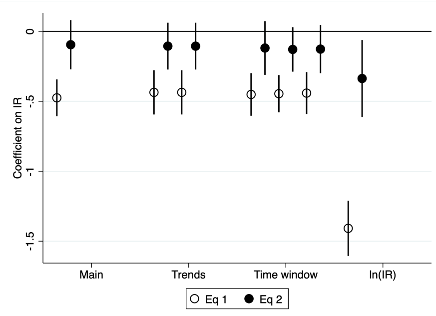
(a) LBW



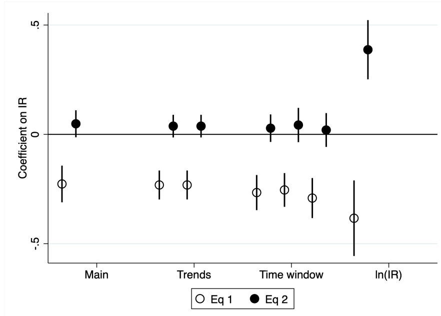
(b) FDR



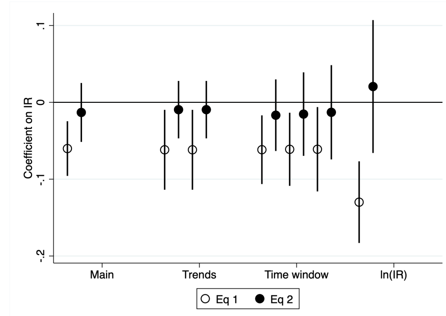
(c) IMR



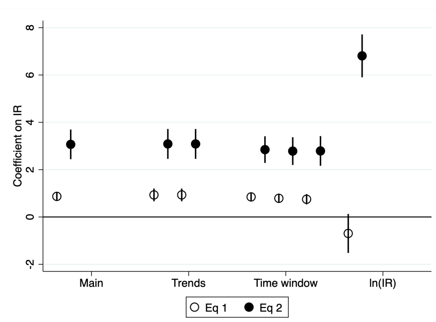
(d) Preterm



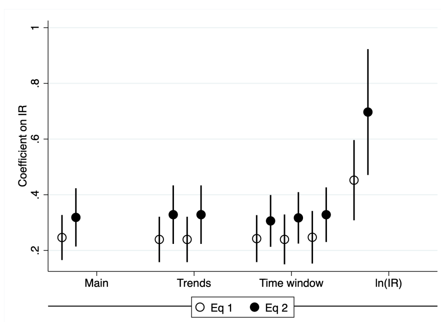
(e) Hypertension



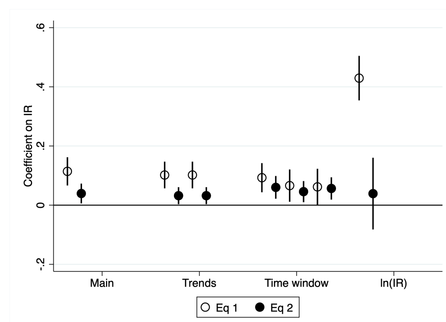
(f) Eclampsia



(g) Tobacco



(h) Alcohol



(i) Prenatal Care

This table reports the results of regressing equations 1 and 2. Dependent variable indicated in subfigure caption. First two dots reproduce pooled effect from previous figures. Second grouping adds linear and cubic CZ-specific time trends. Third grouping shortens the time window included from 1990 – 2000 to 1991 – 1999, 1992 – 1998, and 1993 – 1997 in that order. The final group replaces the incarceration rate per 100 men with the natural log of the women's partner market incarceration rate, assigned as described in section 5. Vertical lines indicate 95% confidence interval. Standard errors clustered by CZ of residence.

9 Tables

Table 1: Summary statistics

Variable	Mean	Std. Dev.	N
A. Mothers' characteristics			
Age	25.856	5.657	1151764
Black	0.281	0.449	1151764
Married	0.683	0.465	1151696
Less than HS	0.219	0.413	1150021
HS grad	0.362	0.481	1150021
Some college	0.218	0.413	1150021
College grad	0.201	0.401	1150021
Partner-market incarceration rate	0.01	0.01	1151764
B. Birth outcomes			
Birth weight (g)	3302.392	636.23	1151339
Low birth weight	0.085	0.279	1151341
Very low birth weight	0.018	0.132	1151341
Pre-term	0.125	0.331	1150643
Received pre-natal care	0.988	0.111	1146785
Smoked during pregnancy	0.171	0.377	1149619
Drank during pregnancy	0.015	0.122	1148075
Hypertension	0.048	0.215	1151370
Eclampsia	0.006	0.076	1151370
Fetal alcohol syndrome	0.0001	0.01	1151245

Table 2: Summary statistics, by race

Variable	Mean	Std. Dev.	N	Mean	Std. Dev.	N
		White			Black	
A. Mothers' characteristics						
Age	26.498	5.548	828290	24.212	5.603	323474
Married	0.818	0.386	828241	0.337	0.473	323455
Less than HS	0.199	0.4	827020	0.267	0.443	323001
HS grad	0.333	0.471	827020	0.437	0.496	323001
Some college	0.223	0.416	827020	0.205	0.404	323001
College grad	0.244	0.430	827020	0.091	0.287	323001
Partner-market incar rate	0.004	0.001	828290	0.025	0.008	323474
B. Birth outcomes						
Birth weight (g)	3380.028	605.055	828033	3103.557	670.021	323306
Low birth weight	0.066	0.249	828034	0.134	0.34	323307
Very low birth weight	0.012	0.109	828034	0.032	0.177	323307
Pre-term birth	0.102	0.303	827723	0.183	0.387	322920
Received pre-natal care	0.993	0.082	825172	0.973	0.162	321613
Smoked during pregnancy	0.186	0.389	826883	0.133	0.34	322736
Drank during pregnancy	0.012	0.109	825760	0.023	0.15	322315
Hypertension	0.049	0.216	828031	0.047	0.212	323339
Eclampsia	0.005	0.071	828031	0.008	0.089	323339
Fetal alcohol syndrome	0.00007	0.008	827931	0.0002	0.014	323314

Table 3: Incarceration and Infant Health

	Infant Health Ix		LBW		FDR		IMR	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
All mothers								
Both races IR	-0.008	-0.017	-0.381***	0.156*	-0.002	0.032	-0.033***	-0.007
	(0.013)	(0.012)	(0.047)	(0.058)	(0.018)	(0.023)	(0.010)	(0.012)
N	1106307	1106307	1113741	1113741	92950	90894	92950	90894
Black								
IR	-0.007	-0.018	-0.291***	0.124*	0.018	0.028	-0.023*	0.018
	(0.013)	(0.012)	(0.045)	(0.058)	(0.017)	(0.019)	(0.009)	(0.011)
N	306817	306817	310002	310002	39320	38727	39320	38727
White								
IR	-0.036	-0.072+	-2.314***	0.023	-0.380***	-0.140*	-0.201***	-0.009
	(0.037)	(0.038)	(0.231)	(0.180)	(0.072)	(0.066)	(0.036)	(0.036)
N	799490	799490	803739	803739	53630	52167	53630	52167

Notes: This table reports the results of regressing equations 1 and 2. Top row denotes the dependent variable. IMR and FDR regressions weighted by the number of births in the cell. Includes years 1990 – 2000. Standard errors clustered by CZ of residence. + $p < 0.1$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4: Incarceration and Maternal Stress

	Mat Health Ix		Preterm		Hyper		Eclampsia	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
All mothers								
Both races IR	0.112	-0.214^{+}	-0.475***	-0.095	-0.227***	0.048	-0.060***	-0.013
	(0.103)	(0.107)	(0.064)	(0.085)	(0.041)	(0.030)	(0.017)	(0.019)
N	1083535	1083535	1113101	1113101	1113762	1113762	1113762	1113762
Black								
IR	0.099	-0.333***	-0.382***	-0.214*	-0.229***	0.035	-0.055***	0.024
	(0.107)	(0.087)	(0.075)	(0.077)	(0.035)	(0.037)	(0.019)	(0.016)
N	298664	298664	309634	309634	310037	310037	310037	310037
White								
IR	0.273	-1.030*	-2.445***	-0.513*	-0.102	0.816***	-0.195***	-0.047
	(0.337)	(0.399)	(0.255)	(0.229)	(0.200)	(0.173)	(0.054)	(0.078)
N	784871	784871	803467	803467	803725	803725	803725	803725

Notes: This table reports the results of regressing equations 1 and 2. Top row denotes the dependent variable. Includes years 1990 – 2000. Standard errors clustered by CZ of residence. + $p < 0.1$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5: Incarceration and Maternal Health Behaviors

	Tobacco		Alcohol		PNC		1st trim	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
All mothers								
Both races IR	0.870***	3.069***	0.246***	0.319***	0.114***	0.039*	3.131***	1.355***
	(0.092)	(0.303)	(0.039)	(0.051)	(0.023)	(0.016)	(0.369)	(0.164)
N	1112396	1112396	1111351	1111351	1109429	1109429	1109429	1109429
Black								
IR	1.151***	1.824***	0.271***	0.400***	0.087***	0.091***	2.669***	1.789***
	(0.086)	(0.194)	(0.042)	(0.059)	(0.022)	(0.030)	(0.325)	(0.188)
N	309609	309609	309325	309325	308395	308395	308395	308395
White								
IR	-4.891***	7.718***	-0.291*	0.106	0.665***	0.042	12.347***	2.975***
	(1.167)	(0.604)	(0.113)	(0.150)	(0.074)	(0.071)	(1.581)	(0.568)
N	802787	802787	802026	802026	801034	801034	801034	801034

Notes: This table reports the results of regressing equations 1 and 2. Top row denotes the dependent variable. Includes years 1990 – 2000. Standard errors clustered by CZ of residence. + $p < 0.1$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.