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Declining violence and improving birth outcomes in the US: Evidence from birth certificate data

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ABSTRACT

The decline in crime that occurred in the last decade of the 20th century was one of the most important societal changes in recent US history. In this paper, we leverage the sharp decline in violence that began in the 1990s to estimate the relationship between county-level murder rates and individual-level birth outcomes for Black, Hispanic, and White mothers. Using the FBI's Uniform Crime Reporting data from 1992 to 2002 and individual-level data from more than 30,000,000 US birth certificates, we employ two-way fixed effects models with a rich set of controls to compare births to similar women in the same county who experienced different crime rates during their pregnancies. Elevated murder rates are associated with substantially higher risks of low birth weight for White mothers, low birth weight and small for gestational age among Black mothers, and small for gestational age among Hispanic mothers. Sensitivity analyses show that the existence of confounders that would invalidate these inferences is highly unlikely, suggesting that we have identified causal relationships, even if some uncertainty about the precision of our estimates remains. These findings have potential implications for prenatal and postpartum care, and they add to a growing body of evidence showing that the "Great American Crime Decline" was strongly linked to improved outcomes among groups that experienced the steepest declines in violence.

1. Introduction

One of the most important large-scale changes in recent US history is the dramatic decline in violent crime that occurred over the last three decades (Blumstein and Wallman, 2006; Zimring, 2007; Sharkey, 2018b). Between 1991 and 2019, crime rates dropped by more than 50% across the nation, with declines above 75% in some cities (Federal Bureau of Investigation, 2015; 2021). As a result of this "Great American Crime Decline", violent crime rates across most cities remain markedly below their early-1990s levels. Much of the literature has focused on understanding its causes (Levitt, 2004; Zimring, 2007), but we know less about its consequences for communities and individuals.

The benefits of the crime decline are likely particularly large for Black and Hispanic youth. Because exposure to violence has large negative impacts on children (Sharkey, 2018a), the decline in crime greatly benefited younger generations who grew up in much safer environments. Furthermore, links between racial segregation and the spatial concentration of crime imply that the crime decline reduced Black-White and Hispanic-White disparities in exposure to crime (Light and Ulmer, 2016), with implications for downstream outcomes such as academic achievement and economic mobility (Sharkey and Torrats-Espinosa, 2017; Torrats-Espinosa, 2020). Here, we examine the possibility that such benefits extend even earlier, to health at birth.

Racial health inequality has long been known to start in-utero (Conley et al., 2003; Aizer and Currie, 2014). However, a number of these early-life disparities have changed dramatically in recent decades. Patterns of both birth weight and infant mortality have diverged for Black and White mothers since the early 1990s, with increases in adverse outcomes for White mothers and some declines for Black mothers (Mark, 2021; Powers, 2013). The causes of this divergence remain understudied.

We examine the relationship between changes in homicide rates and adverse birth outcomes in the US. We build on the literature on the effects of environmental stress felt during pregnancy, which has documented impacts of exposure to natural disasters (Torche, 2011), military conflict (Torche and Shwed, 2015), terrorist attacks (Brown, 2020), and violence (Torche and Villarreal, 2014; Brown, 2018). The sharp decline in violent crime that began in the early 1990s provides a unique

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opportunity to examine how community-level changes in murder rates relate to infant health.

We combine a two-way fixed effects strategy and sensitivity analyses. The fixed effects strategy allows us to compare births to similar women[1] in the same county who experienced different murder rates during their pregnancy, while accounting for common time trends. The sensitivity analyses characterize an unmeasured confounder that could overturn our findings.

For Black mothers, we find that each additional murder per 100,000 residents was associated with an increase in the probability of low birth weight (<2500 g, LBW) of 0.020 percentage points and the probability that the infant will be small for gestational age (SGA) of 0.014 percentage points. For Hispanic mothers, each additional murder per 100,000 residents was associated with a 0.020 percentage point increase in the SGA probability. For White mothers, each additional murder per 100,000 residents was associated with a 0.004 percentage point increase in the probability of LBW. These associations are driven by counties that had the highest violence levels in the early 1990s. Considering the large scale of the "Great American Crime Decline," these magnitudes are meaningful and explain an important part of the decline in adverse birth outcomes for racial and ethnic minorities between 1992 and 2002.

Sensitivity analyses show that a confounder that would invalidate our inference would have to be more strongly correlated with murder rates and birth outcomes than any of the individual- and county-level controls included in our models. We find the existence of such a confounder highly implausible. Although our study design does not allow us to make causal claims, the results strongly suggest that the crime decline improved infant outcomes, particularly for racial minorities.

2. Trends in violent crime and birth outcomes in the US

Over the past three decades, violent and property crime have experienced one of the largest and steadiest declines in modern history. Between 1991 and 2019, the national homicide rate declined from 9.8 to 5 homicides per 100,000 residents, the national violent crime rate declined from 758 to 379 crimes per 100,000 residents, and the national property crime rate declined from 5,140 to 2,109 crimes per 100,000 residents (Federal Bureau of Investigation, 2021). From 1991 to 2002, the period of our study, the national homicide rate fell from 9.8 to 5.6 homicides per 100,000 residents, the national violent crime rate fell from 758 to 494 crimes per 100,000 residents, and the national property crime rate fell from 5,140 to 3,630 crimes per 100,000 residents (Federal Bureau of Investigation, 2021). In virtually every major city in the country, crime rates today are lower than their levels in the early 1990s. At the neighborhood level, the drop in violence has been relatively larger in the most disadvantaged neighborhoods (Friedson and Sharkey, 2015).

During the same period, patterns of birth outcomes were also changing. On average, birth weights declined from 1990 to 2015, with the rate of LBW births increasing from 6.97% in 1990 to 7.57% in 2002 and 8.28% in 2018 (Martin et al., 2017, 2019). However, in the 1990s, trends for White and Black mothers ran in opposite directions: rates for White mothers increased from 5.61% in 1990 to 6.60% in 2000 while they declined from 13.32% to 13.07% for Black mothers (Martin et al., 2017). There were slight increases among Hispanic mothers, from 6.06% to 6.41%. Trends in preterm birth for singleton births followed similar patterns, with increases for White mothers (from 7.54% in 1990 to 8.98% in 2001), declines for Black mothers (from 17.85% to 16.01%), and only slight increases for Hispanic mothers (Martin et al., 2003).

Research has offered few explanations for these diverging patterns. Notably, the divergence in trends between Black and White mothers was concentrated in a few states (Mark, 2021), suggesting that the variables influencing the divergence varied with geography. Recent work explains the overall declines in birth weight through a combination of reduced intra-uterine growth (Donahue et al., 2010) and an increased prevalence of induced and cesarean deliveries occurring at earlier gestational ages (Tilstra and Masters, 2020). A further contributing factor is that multiple births, which are at higher risk of adverse birth outcomes, also became more common (Martin et al., 2003, 2019). Yet there is no evidence that these factors trended differently for Black and White mothers (Tilstra and Masters, 2020), and so the diverging trends by race/ethnicity remain a puzzle.

Exposure to violent crime could explain part of this divergence. Lower levels of violent and property crime have been linked to better economic mobility outcomes among low-income households (Sharkey and Torrats-Espinosa, 2017) and smaller racial/ethnic gaps in school outcomes (Torrats-Espinosa, 2020). And while crime is a prominent area of focus in the public health literature, the impact of the crime decline on public health outcomes has been largely ignored (for a notable exception, see Sharkey and Friedson (2019)). The scale of the crime decline, coupled with its spatial concentration, suggests that even if crime had only small effects on birth outcomes, the crime drop of the 1990s would have disparately positive impacts on the health of babies born to Black mothers.

3. Links between violent crime and birth outcomes

The primary mechanism by which violent crime could affect health at birth is through stress, which has been shown to negatively influence pregnancy and birth outcomes (Torche, 2011; Brown, 2020; Duncan et al., 2017). Violence-related stress may impact birth outcomes through multiple mechanisms. A first is biological; stress induces the production of hormones linked to intrauterine growth and early delivery, it leads to changes in the immune system that leave the mother at greater risk of infections that may induce early labor, and it increases blood pressure, which is linked to conditions like hypertension and preeclampsia that affect birth outcomes (Mulder et al., 2002; Wadhwa et al., 2001; Segerstrom and Miller, 2004). A second is behavioral; individuals in high-stress environments may respond by engaging in activities that affect fetal health, such as smoking and other coping behaviors (Pickett et al., 2009; Jackson et al., 2010). Higher crime rates could also influence pregnant people to stay inside, where they are more likely to be exposed to secondhand smoke and infectious disease. The behavioral response could theoretically have beneficial effects, such as an increased willingness to seek prenatal care (Torche and Villarreal 2014, but see Brown (2018)).

Other potential mechanisms operate at the community level. Higher crime rates are closely linked to limited economic prosperity (Morenoff, 2003). The resulting adverse labor market outcomes and high poverty rates can be a source of stress (Pickett et al., 2009) and additionally affect birth outcomes by reducing nutritional intake (Almond and Mazumder, 2011).

Community-level violence has been shown to cause worse birth outcomes in international contexts such as the Mexican drug war and conflicts in the Middle East (Brown, 2018; Mansour and Rees, 2012; Torche and Shwed, 2015). This work exploits plausibly exogenous geographic variation in outbreaks of violence, thus providing strong causal evidence of their effects. In the US, the rise and subsequent fall in violence was more gradual but affected virtually all urban centers in the country (Sharkey, 2018b). Since the context of exposure to crime in the US is not necessarily comparable, it's unclear whether the "Great Crime Decline" affected birth outcomes in the same way.

The best estimates of the causal impacts of exposure to violent crime in the US were obtained by comparing births to Californian mothers in the same census tracts who were and were not exposed to a homicide in

[1] People of all genders give birth. US birth certificate data assume that gender corresponds to sex assigned at birth and thus it is unclear whether men (or other genders) with a uterus gave birth. For parsimony, we use female nouns and pronouns.

their census tract (Goin et al., 2019). The authors compared births to mothers who were exposed prior to conception, during the first trimester, and during a truncated second trimester. They found minimal differences between exposed and unexposed mothers; there was no relationship between exposure to a homicide in any of the periods and preterm birth; and exposure to a homicide in the first trimester increased the SGA risk by 0.15%. At higher levels of crime, differences were more substantial. Mothers who were exposed to at least one homicide in each period had an SGA risk that was 1% higher than unexposed mothers.

The small estimated effects of exposure to a homicide during pregnancy are surprising given the strong cross-sectional associations between neighborhood violent crime and adverse birth outcomes (Matoba et al., 2019; Masho et al., 2017; Mayne et al., 2018), which hold even after adjusting for a rich set of area-level and individual covariates (Morenoff, 2003). We see two explanations for this discrepancy. One explanation is that unmeasured confounders, such as poverty status and access to health care, could be biasing the correlation between crime rates and adverse birth outcomes upwards. But a second explanation suggests that Goin et al. (2019) actually underestimate the role of violent crime. Goin et al. (2019)'s causal estimates are for a discrete shock: exposure to a specific homicide at the time the mother was pregnant. By contrast, hypotheses about the effects of violence on birth outcomes do not hinge on *specific* events during pregnancy, but rather on *chronic* stress induced by an ecological characteristic of violent neighborhoods: the likelihood of experiencing, witnessing, or being otherwise exposed to violence. Indeed, chronic stressors are much better predictors of adverse birth outcomes than acute stressors (Strutz et al., 2014), so chronic exposure to the potential for violence may be more important than exposure to a single event. Mothers in the same census tracts would likely be quite similar on measures of chronic crime-induced stress because they had been exposed to the same neighborhoods and thus the same baseline levels of violent crime over a longer period.

We build on this literature by using individual data on birth outcomes and county-level crime rates from 1992 to 2002 to estimate the relationship between murder rates experienced by White, Black, and Hispanic mothers and three measures of infant health: LBW, SGA, and preterm birth. These indicators of infant health predict early life outcomes such as infant mortality and have effects on later-life outcomes such as academic achievement and adult well-being (Paneth, 1995; Hack et al., 1995; Reichman, 2005; Almond et al., 2005; Conley et al., 2003; Aizer and Currie, 2014). They are also deeply unequal; in 2018 births to Black mothers were approximately twice as likely to be LBW as births to White mothers, and were 50% more likely to be preterm (Martin et al., 2019). Were chronic exposure to violent crime to affect birth outcomes, it could be a cause of this inequality.

4. Data

We use restricted birth certificate data from the National Center for Health Statistics that include all singleton[2] births to Hispanic (N = 7,678,558), non-Hispanic Black (N = 6,210,468), or non-Hispanic White (N = 24,939,192) women aged 15–39 residing in the US in 1992–2002. Our three outcomes are low birth weight (LBW), small for gestational age (SGA), and preterm birth. Our measure of LBW is coded as 100 if the infant was born weighing less than 2500 g, and 0 otherwise.[3] Our measure of SGA is a similarly coded indicator for whether the infant was born below the 10th percentile for weight by gestational age, using estimates corrected for implausible reports of gestational age from Talge et al. (2014).[4] Preterm birth is likewise coded to indicate whether the infant was born before 37 weeks.

Key independent variables in the analyses are the year, mother's age at birth, race/ethnicity (Black, Hispanic or White), county of residence at birth, and whether the birth is her first or a higher-order birth. We also include mother's education as a measure of socioeconomic status, interacted with age to account for the age dependence of education.[5]

We measure murder rates using county-level homicide data from the FBI's UCR Program. These data include all murders that local law enforcement agencies operating within the county reported to the FBI. Murder rates are measured from 1991 to 2002 in counts per 100,000 residents.[6] Because the socioeconomic conditions of counties impact mothers' well-being, with direct effects on their pregnancies, we also control for county-level time-varying covariates obtained from the 1990 Census, the 2000 Census, and the 2008–2012 American Community Survey, which we linearly interpolate to generate year-to-year variation. Murder rates and time-varying county covariates are lagged one year with respect to the birth outcomes.

The advantage of using the birth certificate data is that they represent practically the entire population of births in the United States over this period. The disadvantage is that the county is the smallest geographic area available, and using an area as large as a county certainly obscures some more localized patterns that could include stronger associations than the ones we will be able to detect.

5. Methods

Our longitudinal data allow us to adjust for both county- and time-specific factors, in addition to individual and time-varying county-level characteristics. We fit the following linear probability model:

$$Y_{ict} = \beta_0 + \beta_1 X'_{ict} + \beta_2 A'_{ct} + \beta_3 M_{ct} + \theta_c + \psi_t + \varepsilon_{ict} \tag{1}$$

In Model 1, the outcome Y_{ict}, measured at the individual level i in each county c and year t, is a function of individual measures (X'_{ict}) and a vector of time-varying county-level covariates that account for socioeconomic characteristics (A'_{ct}): the percent employed among the working age population, the percent unemployed, the percent of housing units that are vacant, the percent of the population in poverty, county median household income, the percent of the population that is Black, White, and Hispanic, and the percent without a high school degree, with a high school degree, with at least some college, and with a college degree. X'_{ict} includes an indicator for whether the birth is a first birth, the four-level measure of mother's education, an indicator for whether the mother was married at the time of birth, a five-level measure of her age at the time of birth (15–19, 20–24, 25–29, 30–34, 35–39), and the two-way interactions between mother's age groups and (a) education level and (b) marital status. The model also includes county fixed effects to account for time-invariant county characteristics (θ_c) and year fixed effects to account for time-varying factors that influence all counties equally (ψ_t). The measure of the murder rate, M_{ct}, varies by year t and

[2] Multiple births are much more likely to be LBW, SGA, and preterm, and are therefore excluded.

[3] We code binary indicators as 0 and 100 to make linear regression coefficients interpretable as changes in percentage points.

[4] Observations excluded for SGA if gestation was less than 21 weeks.

[5] We considered adjusting for health characteristics, including hypertension and smoking during pregnancy, but missingness on these variables was high (~ 20%) and strongly correlated with geography. Furthermore, they are likely to be affected by the same stress variables caused by exposure to crime that theoretically produce the adverse birth outcomes we measure. If so, their inclusion as covariates would bias the results. Estimates adjusting for these variables, limited to the subsample where they were not missing, were substantively similar. Results available on request. Additionally, the birth data do not include complete information on mother's education after 2002. For this reason, we report 1992–2002 analyses as our main findings. Results from models using data from 1992 to 2013 excluding controls for education are very similar and are available on request.

[6] Data from 1993 were not made public, so we impute 1993 values as the average of the 1992 and 1994 values. Results are not sensitive to the exclusion of 1993.

Table 1
Descriptive statistics of counties, by race/ethnicity.

	White	Black	Hispanic
	mean	mean	mean
County Murder Rate per 100,000	5.88	12.86	9.38
Proportion of Births to Mothers in High Murder Rate Counties	0.37	0.74	0.73
Proportion of Births to Mothers in Low Murder Rate Counties	0.63	0.26	0.27
County Percent of Population Employed	60.75	58.49	58.65
County Percent of Population Unemployed	3.65	4.34	4.47
County Percent of Housing Units that are Vacant	8.81	8.45	8.03
County Percent in Poverty	11.77	15.37	15.42
County Median Household Income	38,537.65	36,064.24	39,028.89
County Percent White	78.10	59.45	52.41
County Percent Black	9.89	25.98	10.40
County Percent Hispanic	7.89	10.14	29.88
Proportion of Births that are First Births	1.58	1.62	1.62
Proportion of Births to Women Who are Unmarried	1.21	1.69	1.41
Proportion of Births to Mothers with Less Than High School Education	0.13	0.27	0.51
Proportion of Births to Mothers with High School Diploma Only	0.33	0.40	0.30
Proportion of Births to Mothers with Some College	0.24	0.22	0.13
Proportion of Births to Mothers with College or Higher Education	0.29	0.10	0.07
Number of Births (N)	24,946,756	6,211,922	7,679,267

Note: Data from restricted birth certificate files, Census, ACS, UCR, 1992–2002.

county *c*. Standard errors are clustered at the county level. We estimate this model as OLS regressions fit separately for White, Black, and Hispanic women.

Model 1 compares births to similar women in the same counties at times in which murder rates differed. The coefficient β_3 is an estimate of the relationship between the murder rate and the individual risk of each birth outcome, net of time-invariant county factors, time-varying factors common to all counties, time-varying county socioeconomic conditions included in the model, and the individual covariates. The inclusion of the time-varying county-level covariates adjusts for the effects of community-level factors on birth outcomes. Our estimates are thus an attempt to isolate more direct associations between crime and birth outcomes, primarily occurring through stress-related mechanisms.

The relationship between changes in the murder rate and changes in the likelihood of adverse birth outcomes may by driven by a subset of counties with different baseline levels of crime. We conduct a sub-analysis in which we divide counties into “Low” and “High” groups based on the average murder rate from 1992 to 94 and estimate separate models for each group. The “Low” group is made up of the counties in the bottom 75% of murder rates from 1992 to 94, and the “High” group is the set of counties in the top 25%.

Without exogenous variation in chronic exposure to crime, precise estimates of its causal effects are not attainable. Interpreting our results as causal effects would require reliance on a strong assumption: that there are no unobserved confounders that influence both exposure to crime and birth outcomes that do not operate through any of the county socioeconomic conditions or individual socioeconomic status controls already included in the model. For example, individual income is a strong predictor of birth outcomes and the ability to relocate to counties where crime rates are lower. Our model adjusts for education and marital status, but the birth certificate data do not include income measures. To assess the extent to which our results are driven by an unobserved confounder, like income, we implement two sensitivity tests proposed by Oster (2019) and Frank (2000).

6. Results

Table 1 shows that the counties where Black or Hispanic women lived were significantly more disadvantaged than those where White women lived. More than 80% of Black and Hispanic mothers who gave birth during this period lived in counties in the highest third of murder rates in 1992–94, compared to less than 50% of White mothers. Additionally, counties where Black and Hispanic mothers lived had lower median incomes, higher poverty rates, and higher unemployment rates.

Fig. 1 shows trends in birth outcomes and average exposure to murder rates for White, Black and Hispanic women.[7] Women of all groups experienced steep declines in exposure to murder from 1991 to 2002. The average murder rate in the counties of residence for White mothers fell from about 7.5 to about 4 per 100,000. For Black mothers, the decline was much larger, from about 17.5 to about 8 per 100,000. Patterns for Hispanic mothers are similar to those of Black mothers, though murder rates were lower.

A comparison of the three panels illustrates the large disparities in birth outcomes between Black women and White or Hispanic women. For White and Hispanic women, LBW rates range from 4.5 to 5.5%. For Black women, these rates are more than 10 percentage points higher. Disparities are similar for the other two outcomes. But patterns vary over time. From 1992 to 2002, LBW rates for Black women declined by about 1 percentage point, from 12% to 11%, constituting an 8% decline in the prevalence of LBW. Declines were similar for SGA and preterm birth rates. These changes were not present among White or Hispanic women, for whom LBW and preterm birth rates increased during this period. Indeed, for White mothers, rates of preterm birth increased substantially, from near 7.5% to 9%. Rates of SGA fell for both White and Hispanic mothers, though the magnitudes of the declines were smaller than for Black mothers.

Fig. 2 illustrates the relationship between changes in murder rates and changes in birth outcomes at the county level from 1992 to 2002 for White, Black and Hispanic women. The size of the dots is proportional to the number of singleton births to women in the county in 2002.[8] The first row of graphs shows the relationships for LBW. For White women, the correlation is slightly positive; increases (declines) in the murder rate were associated with increases (declines) in the LBW rate. For Black women, it is also positive, but even more so. But for Hispanic women, there is almost no relationship between changes in the murder rate and the LBW rate. Patterns of SGA are similar to those of LBW, but there appears to be little, if any, relationship between changes in murders and

[7] We compute the group-specific murder rates by creating anational weighted average of county-level murder rates where the weights are the counts of women of each group living in the county. These measures should be interpreted as the murder rate to which the average woman of each racial/ethnic group was exposed in a given year.

[8] Outliers and counties where fewer than 100 births to residents occurred in 2002 are not plotted.

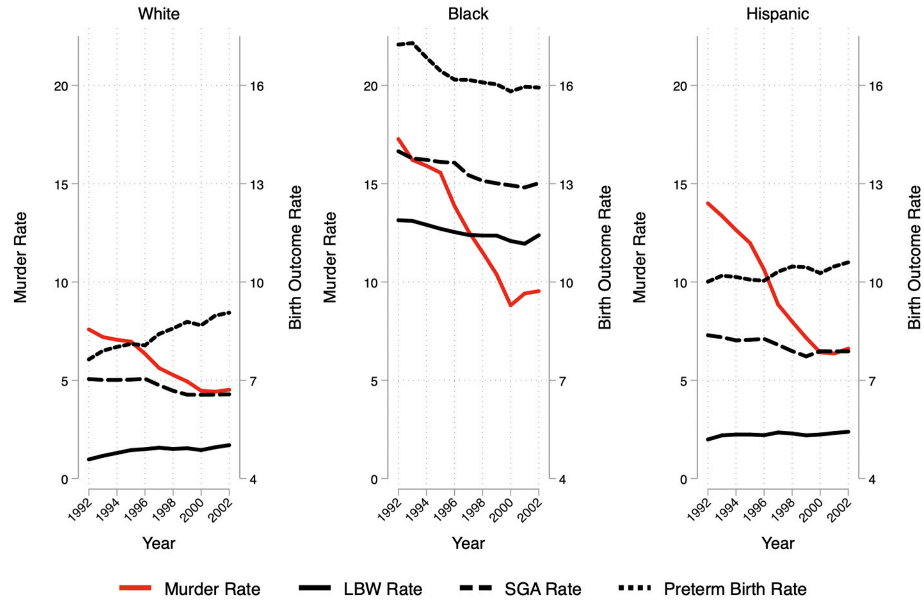

Fig. 1. Murder Rate and LBW, SGA, and Preterm Rate For White, Hispanic, and Black Mothers, 1992–2002. Note: Murder rate and LBW rates are at the county level, weighted by number of births. Data from National Center for Health Statistics restricted birth certificate files, UCR.

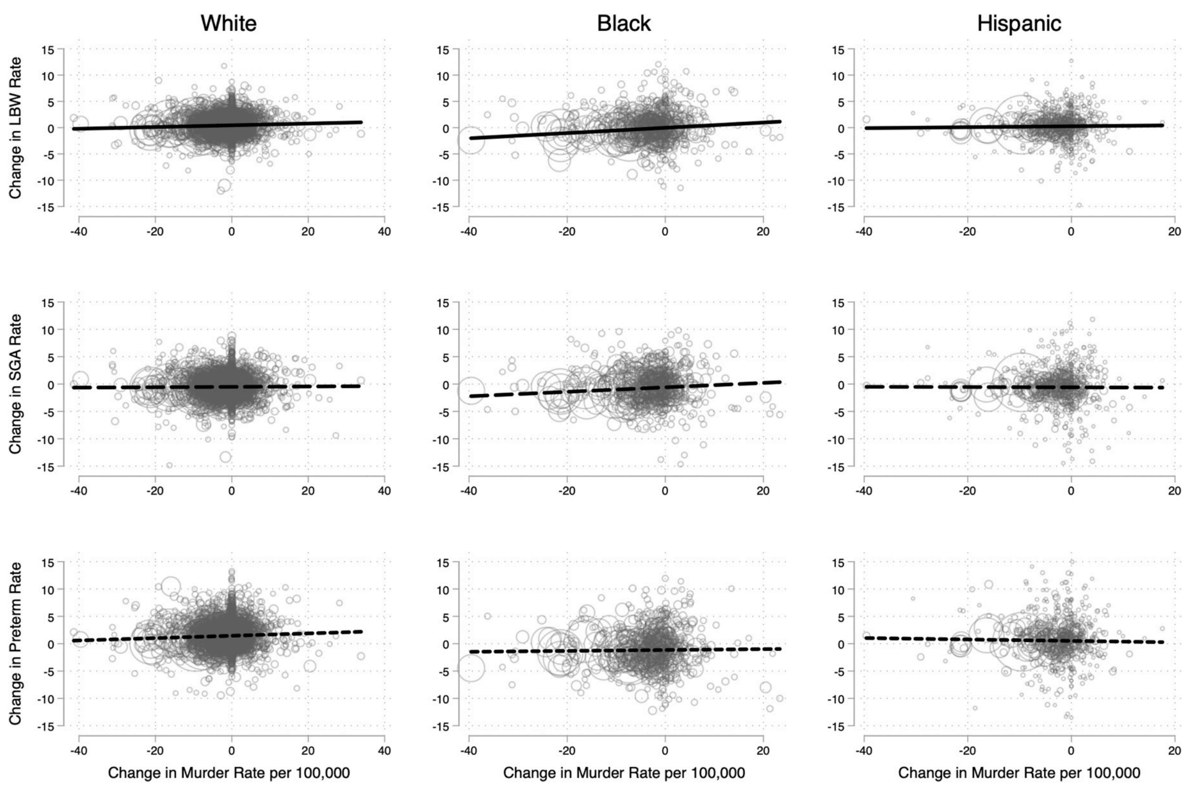

Fig. 2. Changes in Murder Rates and Birth Outcomes from 1992 to 2002, by County and Race/Ethnicity. Note: Change in murder rate and rates of LBW, SGA, and preterm birth from 1992 to 2002, for counties in which there were at least 100 births in both periods. Data from restricted birth certificate files, UCR. The size of circles is proportional to the number of births in the county. The lines are the weighted lines of best fit. Outliers not shown.

changes in rates of preterm birth.

Fig. 3 shows estimates from the regression model (coefficients and standard errors are in Table A1). The relationship between murder and LBW is positive, and it is larger for Black compared to White or Hispanic women. On average, each additional murder per 100,000 people is associated with an LBW rate that is 0.004 (95% CI = 0.001, 0.008) percentage points higher for White women, 0.020 percentage points higher for Black women (95% CI = 0.010, 0.030), and 0.008 percentage points higher for Hispanic women (95% CI = −0.002, 0.017). This pattern is in line with other evidence that the health of US Hispanic mothers exhibits lower correlations with traditional measures of social disadvantage than that of Black mothers (Fuentes-Afflick and Lurie, 1997; Franzini et al., 2001).

Coefficients for SGA are similar to those for LBW, but they vary in

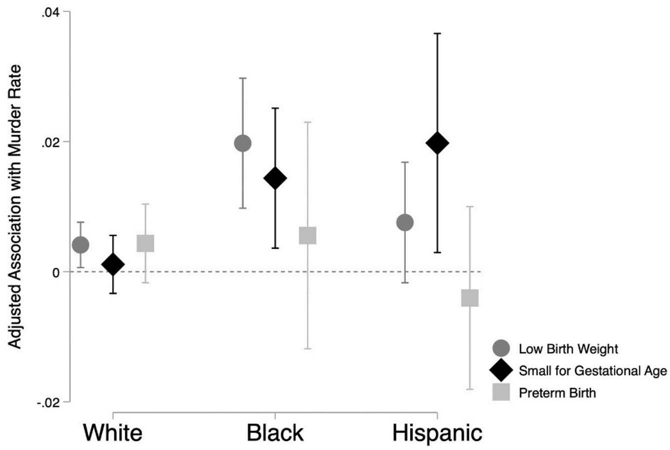

Fig. 3. Association between Murder Rate and Birth Outcomes for White, Black, and Hispanic Mothers, 1992–2002. Note: Data from National Center for Health Statistics restricted birth certificate files, Census, ACS, and UCR. Results from Model 1 with 95% CIs.

some important respects. First, they are significantly closer to zero for White women (0.001; 95% CI = −0.003, 0.006), suggesting that there is little relationship between the murder rate and SGA for babies born to White mothers. For Black mothers, the coefficient on SGA is similar to that on LBW (.014; 95% CI = 0.004, 0.025). The largest difference was for Hispanic mothers, where estimated coefficients on SGA were 0.020 (95% CI = 0.003, 0.037).

There were no statistically significant associations between the murder rate and preterm birth, though the estimate for White mothers is larger than for the other outcomes (0.006, 95% CI = −0.002, 0.010). Estimates for Black and Hispanic mothers were 0.006 and −0.004, respectively (95% CIs = −0.012, 0.023 and −0.018, 0.010). This is consistent with Goin et al. (2019), who find no effects of a neighborhood murder during pregnancy on preterm birth rates. The non-relationship between crime and preterm birth remains a puzzle deserving attention in future research.

Fig. 4 displays the estimates by baseline crime rate in 1992–94. For the high-crime group, results were similar to the aggregate results in Fig. 3. Results for White women were similar across both types of counties. But estimates differed by baseline crime rate for Black and Hispanic women, with larger relationships in high-crime counties and smaller ones in low-crime counties.

7. Sensitivity analyses and robustness checks

7.1. Sensitivity to unmeasured confounding

In this section, we supplement the fixed effects models with two tests of sensitivity to unmeasured confounding. The idea is to characterize an omitted variable (or set of variables) that would change the conclusions of our findings so that the coefficient on murder would become zero if that variable could be measured and included in our models. We do so by estimating the predictive power that such an omitted variable would have to have on birthoutcomes and on exposure to murder. Such a variable potentially exists in a statistical sense, but what our sensitivity analysis allows us to assess is whether it is likely to exist in the real world. Once we have estimated the predictive power that the confounder would need to have on birth outcomes and on exposure to murder, we can compare that to the predictive power that other controls in our model have on the outcome and on exposure to murder. Seeing, for example, that the confounder would need to be twice as predictive of birth outcomes and exposure to murder as mother's education would lead us to conclude that such variable is unlikely to exist.

We present results from two different sensitivity tests that accomplish the exercise that we just described – one test is proposed by Oster (2019) and the other by Frank (2000). Oster's test allows for a set of unobserved covariates that could reduce the coefficients on the murder rate to zero. The idea is to estimate two characteristics of a confounder variable: the predictive power that this variable would have on birth outcomes and its importance in predicting the murder rate, relative to the full set of covariates already included in the model. Frank's test estimates the correlations that an omitted variable would have to exhibit with the outcome and the independent variable of interest such that when adjusting for that variable in the model, the inference would be invalidated at the 5% level (i.e., the 95% confidence interval around the point estimate of interest would include 0).

Results from the Oster (2019) sensitivity analyses are in Fig. 5. The

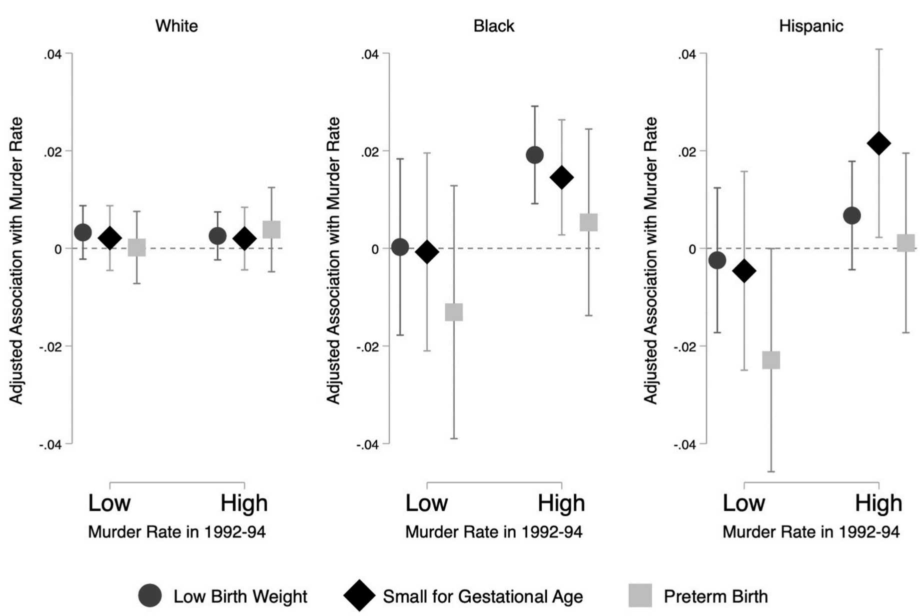

Fig. 4. Association between Murder Rate and Birth Outcomes for White, Black, and Hispanic Mothers, 1992–2002, by Level of Murder Rate in 1992–94. Note: Data from National Center for Health Statistics restricted birth certificate files, Census, ACS, and UCR. Results from Model 1 with 95% CIs. Counties in the "Low" baseline crime category were in the bottom 75% of crime rates in years 1992–94. Counties in the "High" category were in the top 25%.

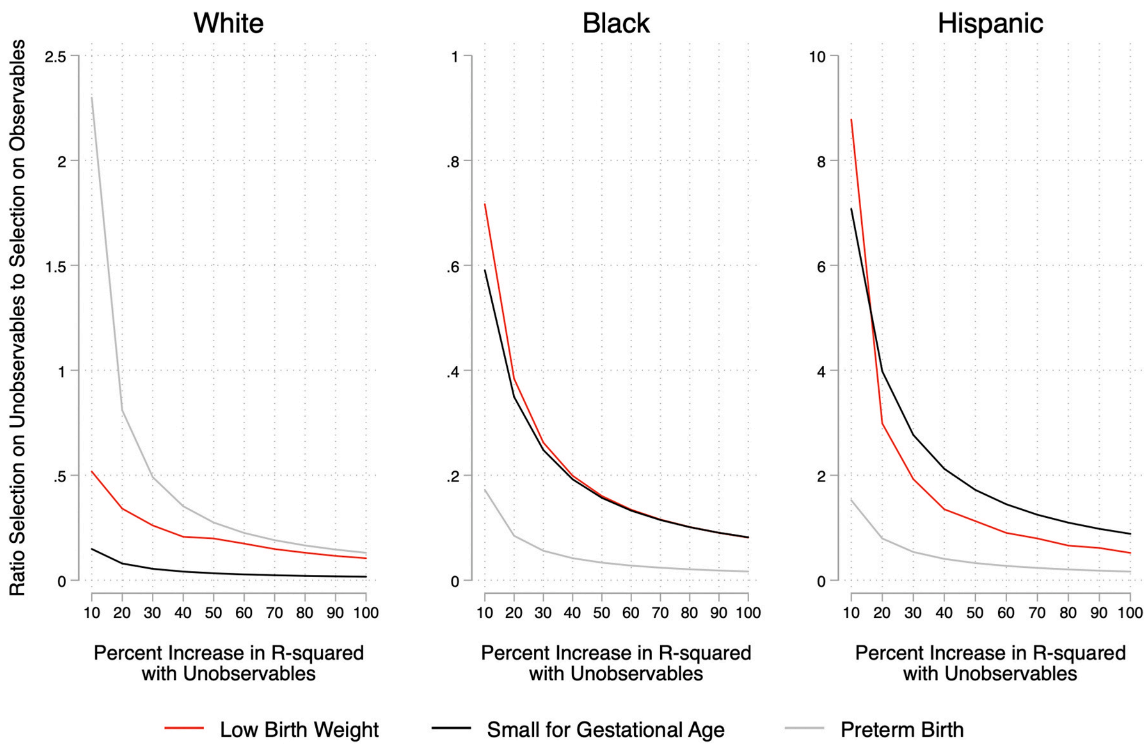

Fig. 5. Sensitivity Analyses from Oster's Test of Relative Degree of Unobserved Selection. Note: Estimates using the method in Oster (2019) on results from Model 1. The y-axis represents the strength in predicting the outcome of an unmeasured confounder, relative to the covariates already included in the model. The x-axis represents the R^2 from a hypothetical regression including all covariates, the two sets of fixed effects, and the unmeasured confounder. The curves represent the pairs of x and y values that would make the association between murder and the outcome equal to zero.

x-axis shows the percent change in the R^2 from a hypothetical regression that adds a set of unobserved covariates to the regression that already includes the controls in the model. The y-axis shows the importance that the unobserved covariates would need to have in predicting the murder rate, relative to all of the controls that are already in the model. The curves represent the pairs of x and y values that would yield a zero coefficient on the murder rate if the unobserved confounder were added to the model.

For example, the pair of values (20, 0.5) represents a hypothetical set of unobserved covariates that have a predictive power on murder that is half of the predictive power that *all* controls in the model jointly have on murder, *and* that when added to the regression increases the R^2 by 20%. To assess whether such a confounder exists, it is useful to evaluate the predictive power on murder that our model's individual- and county-level controls exhibit. Regressing murder on the individual- and county-level controls, including county and year fixed effects, we obtain an R^2 of 0.81 for White women, 0.88 Black women, and 0.86 for Hispanic women. About half of this R^2 can be attributed to the poverty rate, median income, and racial makeup of the county. Thus to reduce the magnitude of the coefficient on crime to zero, a hypothetical set of unobserved covariates at the point (20, 0.5) would need to have a predictive power on crime similar to some of the strongest community-level predictors of murder rates that the literature has documented *and* would need to increase the R^2 in the outcome regressions by 20%.

The sensitivity results vary by race/ethnicity and the outcome.[9] The existence of a confounder that would reduce the coefficient on crime to zero is quite plausible for the outcomes where coefficients were small, including LBW for White mothers. But for the outcomes were coefficients were large (LBW and SGA for Black mothers and SGA for Hispanic mothers) it is much less plausible. For Black mothers, scenarios in which an unobserved confounder reduces the murder coefficient to zero in the LBW and SGA models are highly unlikely. For example, a potential confounder would have to increase the R^2 of the model by 10% *and* be about 60% as predictive of LBW as *all* of the other covariates combined. Considering that the model includes important individual-level covariates such as age, marital status, and education, and that

[9] The differences across racial groups and outcomes have to do, in part, with the size of the estimated coefficient for which we are running the sensitivity test. Since we are assessing what would it take to turn the coefficients to zero, generally, smaller coefficients will be attenuated to zero by a confounder that exhibits less predictive power on murder and/or increases the R^2 of the regression by a smaller relative amount. The much larger scale for the Hispanic coefficients may be due to the fact Hispanic health outcomes generally exhibit weaker correlations with social disadvantage than other racial/ethnic groups' (Fuentes-Afflick and Lurie, 1997; Franzini et al., 2001). Indeed, coefficients from Model 1 for the community-level covariates were typically much smaller for Hispanic than for White or Black mothers. Similarly, White mothers' birth outcomes are less sensitive to changes in these community-level characteristics than those of Black mothers, consistent with theories of Fundamental Causes of Health that predict that more advantaged people are better able to mobilize health-improving resources (Link and Phelan, 1995; Phelan and Link, 2015).

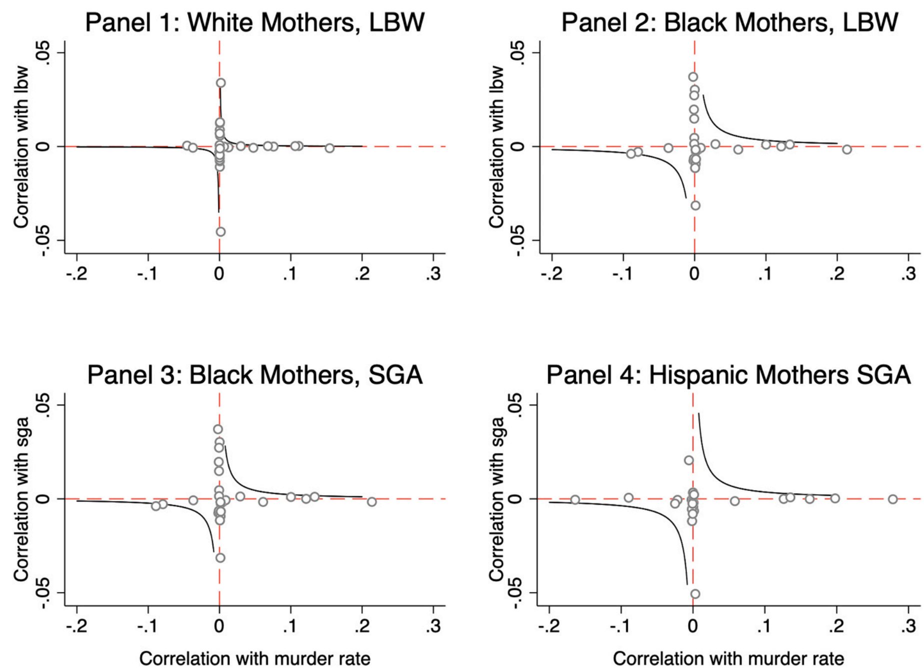

Fig. 6. Sensitivity Analysis using Frank's Test. Note: The y-axis (x-axis) represents the partial correlation between the covariate and the outcome (the murder rate) if such covariate was added to the set of controls already included in Model 1. The curves represent the pairs of partial correlations that an omitted variable would have to exhibit with the outcome and the murder rate to make the point estimate in Fig. 3 statistically non-significant at the 5% level.

the county-level controls and the two sets fixed effects have already a very strong predictive power on murder, such a confounder would have to be quite important. For SGA among Hispanic mothers, the bar is even higher. A confounder of SGA would have to be at least as predictive as all of the other variables combined to reduce the coefficient on the murder rate to zero, even if it doubled the R^2 of the model. It is unlikely that a covariate, even one as important as income, could affect the estimates in this way.

Results from Frank's sensitivity test, which estimates the characteristics of confounders that would make the coefficient's confidence interval include zero, are shown in Fig. 6. We run these sensitivity tests only for models that yield statistically significant associations at the 95% level: LBW for White mothers, LBW and SGA for Black mothers, and SGA for Hispanic mothers. The curved solid lines in the first and third quadrants in each panel of Fig. 6 represent the combinations of partial correlations of a confounder with the corresponding outcome and the murder rate that would invalidate the inference. Any omitted variable whose partial correlations sit on the curves would make the 95% confidence interval around the point estimates in Fig. 3 cross zero.

To assess the extent to which any of the pairs of correlations that would invalidate the inference are plausible, it is useful to compare them to the partial correlations that the covariates already included in the model exhibit with the murder rate and the birth outcomes. The circles in Fig. 6 plot the correlations with the outcome and the murder rate for each covariate in the model. Circles that are in the area between the curves and the origin of the x- and y-axis represent covariates that exhibit correlations with the outcome and the murder rate that are weaker than the ones that a confounder would need to have. In other words, seeing a circle to the right of the curve in the first quadrant or to the left of the curve in the third quadrant would indicate that the confounder that would invalidate our inference is weaker, in terms of correlations with the outcome and murder, than another variable observed in our data.

Looking at where the circles in Fig. 6 sit in relation to the curves, we find that for Black and Hispanic mothers almost all covariates, even important indicators of socioeconomic status like education and community-level variables like median income and the poverty rate, show weaker correlations with the murder rate and birth outcomes than those required for a confounder that would invalidate the inferences in the LBW and SGA models for Black mother and in the SGA model for Hispanic mothers. Indeed, most of the variables sit very close to either the x- or y-axis, implying that they are correlated with either SGA or murder rates, but not both. Only marital status sits slightly over the line. Thus while it is statistically possible for such a confounder to exist, the results in Fig. 6 imply that it would have to be more highly correlated with the outcomes and the murder rate than almost all of the other already strong predictors. Though it remains within the realm of possibility, particularly for White mothers and LBW, it is highly implausible for Black and Hispanic mothers and LBW and/or SGA.

8. Discussion

Our results strongly suggest that exposure to area-level violent crime plays a role in birth outcomes. The largest coefficients were among Black mothers for LBW and SGA, and Hispanic mothers for SGA. Sensitivity and robustness analyses show that the existence of a set of confounders that would invalidate these results is very unlikely, implying that we have plausibly identified the direction of the causal effect even if magnitudes of our estimates remain imprecise. Our results were consistent only in counties with the highest crime rates in 1992–94. If interpreted causally, which as we note should only be done with caution, these results suggest that reducing exposure to violence would reduce racial/ethnic disparities in birth outcomes.[10]

These findings suggest that effects may be broader than specific localized impacts of acute exposure to violent crime during pregnancy estimated in past work (Goin et al., 2019). We find that, for Black and Hispanic mothers, a decline in the homicide rate of 1 per 100,000 is

[10] Estimates of the effects of crime on Black-White and Hispanic-White gaps in adverse birth outcomes are in Appendix Table A2. We estimate that a decline of 1 murder per 100,000 is associated with a 0.02 percentage point decline in Black-White gaps in LBW and SGA and a 0.04 percentage point decline in Hispanic-White SGA gaps.

associated with a decline in the risk of SGA that is similar in magnitude to the effects identified by Goin et al. (2019) of being exposed to at least one homicide in the preconception period *and* in *both* the first and second trimester. Thus both direct and indirect exposure to violence are likely important contributors to adverse birth outcomes, and the decline in crime that occurred from 1992 to 2002 appears to have had positive effects on birth outcomes for babies born to Black and Hispanic mothers.

Even if these results were not interpreted causally, they still provide important lessons for public health. We find that mothers who live in areas with high crime rates are clearly more likely to experience adverse birth outcomes, even after taking many of their individual and their county's characteristics into account. This suggests that a trauma-informed approach to prenatal and postpartum care would improve outcomes were it to be attuned to the stressors affecting mothers in high-crime areas, including the potential for exposure to violence.

The heterogeneous relationships we observe by race/ethnicity and by the level of crime in the county deserve further scrutiny. A likely explanation is that, even within counties, the spatial concentration of crime combined with the racial segregation of American residential life creates large variation across groups in actually experienced changes in crime. The larger coefficients for racial minorities may be evidence that their local experiences of crime fell more than the average crime rate in the county. Our estimates of relationships between birth outcomes and county-level murder thus cannot be interpreted as estimates of the same relationships at more localized levels. Future research should attempt to estimate the geographic level at which violent crime is related to birth outcomes, which would permit more precise estimates of the impacts of area-level violence and would help explain the heterogeneous relationships we find by race/ethnicity and by baseline crime rates.

These findings add to the extensive literature linking neighborhoods, inequality in health outcomes, and the social determinants of health (Ellen et al., 2001; Kramer and Hogue, 2009; Marmot, 2005). Harmful contextual factors that surround individuals (e.g., residential segregation) have been linked to negative health outcomes such as lower life expectancy, higher infant mortality, and worse self-rated health. A common theme across this work is that racial minorities bear the highest costs of growing up in conditions of contextual disadvantage, a finding that also holds true in our study.

The study contributes to a growing literature on the impact that the "Great Crime Decline" has had on individuals and communities (Sharkey and Torrats-Espinosa, 2017; Sharkey, 2018b; Torrats-Espinosa, 2020; Zimring, 2007). Since the early 1990s, the national murder rate has fallen by more than 50%, and in some cities the decline has been even more pronounced (Federal Bureau of Investigation, 2015; 2021). Such dramatic improvement in the quality of life and safety is one of the most remarkable transformations that American cities have experienced in recent decades. Much of the scholarship on the decline in violence has focused on its causes, and we are just beginning to unpack its consequences. This study is a step in that direction.

Finally, it is important to keep in mind that the fraction of the racial/ethnic disparity in birth outcomes that could be explained by disparities in exposure to violent crime is very small. These broader disparities, a result of centuries of structural racism and racial segregation, mean that exposure to violent crime is but one of many factors that compound disadvantage for racial minorities in the United States.

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Author statement

Mark: Conceptualization, Methodology, Formal analysis, writing, Resources.Torrats-Espinosa: Conceptualization, Methodology, writing, Resources.

Appendix

Additional Tables and Figures

Table A1
Regression Output from Model 1

Race	Outcome	Coefficient	StdErr	Observations
White	LBW	0.0041	0.0018	24,929,619
White	SGA	0.0011	0.0023	24,793,161
White	Preterm	0.0043	0.0031	24,816,178
Black	LBW	0.0197	0.0051	6,204,992
Black	SGA	0.0144	0.0055	6,150,395
Black	Preterm	0.0056	0.0089	6,168,169
Hispanic	LBW	0.0076	0.0047	7,675,187
Hispanic	SGA	0.0198	0.0086	7,524,168
Hispanic	Preterm	−0.0040	0.0072	7,530,921

Note: Data from restricted birth certificate files, Census, ACS, UCR. Results from Model 1. Observations excluded for SGA if gestation was less than 21 weeks.

Table A2
Estimates of Association between County-level Murder and Racial/Ethnic Gaps in Birth Outcomes

Outcome	LBW	SGA	Preterm
Black-White Gap	0.02**	0.02**	−0.00
	(0.01)	(0.01)	(0.01)
Hispanic-White Gap	−0.00	0.04**	−0.01
	(0.01)	(0.01)	(0.01)

Note: Data from restricted birth certificate files, Census, ACS, UCR. Controls include average individual characteristics of both groups for each county/year observation, average county characteristics in each year, and county and year fixed effects. Standard errors are clustered at the county level. Observations are weighted by the number of births to Black or Hispanic women in the county/year.

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