Title: Police Violence and the Health of Black Infants

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Abstract:

Police use of force is a controversial political issue, but the broader consequences and spillover effects are not well understood. This article provides causal evidence of the impact of maternal exposure to local police killings of unarmed Blacks during pregnancy on the health of Black infants. Based on a pre-registered, quasi-experimental design and data from 3.9 million birth records in California from 2007 to 2016, the findings show that police killings of unarmed Blacks substantially decrease the birth weight and gestational age of Black infants residing nearby. The size of the effect is proportional to the distance to the event. However, there is no discernible effect on white and Hispanic infants or for police killings of armed Blacks and other race victims, which suggests that the impact of police killings primarily reflects stress and anxiety related to perceived injustice and discrimination. Police violence thus has spillover effects on the health of newborn infants that contribute to the stark and enduring Black-white disparities in infant health and therefore the intergenerational transmission of disadvantage at the earliest stages of life.

One Sentence Summary: Evidence from a quasi-experiment in California shows that maternal exposure to police killings of unarmed Blacks during pregnancy negatively impacts the health of Black infant.

Main Text:

On August 9, 2014, Officer Darren Wilson of the Ferguson Police Department fatally shot Michael Brown Jr., an 18-year-old African American man, in the city of Ferguson, Missouri, a suburb of St. Louis. The event and other well-publicized cases in 2014 brought renewed and national attention to police killings and police use of force more broadly. Recent data shows that police kill about a thousand individuals each year in the United States and approximately 100,000 are admitted to hospital emergency rooms for non-fatal injuries inflicted by law enforcement officers (*1*–*3*). Police killings and other forms of police violence disproportionally affect minority groups and particularly Black Americans (*3*–*5*). In fact, the rate of police killings is almost three times higher among Blacks compared to Whites (*4*). The consequences are stark for victims and their families, but the toll of police violence may extend to entire communities with spillover effects on those living nearby (*6*). This study examines the impact of in utero exposure to police killings of unarmed Blacks in the residential environment on the health of Black infants. To investigate the potential mechanisms, it also compares the effects across racial/ethnic groups and examines the impact of police killings of armed and unarmed Black, white and Hispanic victims.

Racial disparities in infant health are a major and persisting public health concern (*7*). The infant mortality rate is now twice as high among (non-Hispanic) Black compared to white infants: 11.3 per 1,000 Black versus 4.9 per 1,000 white babies (*8*, *9*). The rate of low birth weight (below 2,500 grams) for non-Hispanic Black women is 1.96 times higher than the rate for white women with similar disparities in premature birth (<37 weeks gestational age) and other indicators of infant health (*10*). These racial disparities in infant health have long-term consequences for cognitive development, test scores, ADHD and others outcomes (*11*, *12*). A growing body of research highlights the importance of chronic stress related to experiences of racism and discrimination in explaining the persisting Black-white disparities in infant health and ultimately individual outcomes throughout the life course (*13*–*17*). Previous research, however, largely relies on cross-sectional studies and struggles to identify the underlying processes that explain the relation between different aspects of racism and birth outcomes (*14*, *17*).

Exposure to police killings in the residential environment or through news reports can trigger acute stress, fear, trauma and anxiety particularly for Blacks who perceive injustice and discrimination or fear future police encounters for themselves, their family members or their unborn child (*13*, *18*). For Black women who are pregnant, this exposure and related stress can negatively shorten the length of gestation, impact birth weight, and increase the risk of other adverse health outcomes (*19*). Acute, maternal stress during pregnancy is a likely biological mechanism linking environmental stressors such as police violence in the residential environment to birth outcomes (*13*, *16*). Stress and anxiety lead to the production of placental corticotrophin-releasing hormone (CRH), which increase the risk of reduced gestational age at birth and low birth weight (*20*–*22*). This negative effect of maternal stressors on birth outcomes should be more pronounced for police killings of unarmed victims that are perceived as unjustified. It likely depends on the distance to the event and the timing of exposure with several studies suggesting that exposure to stressors in early pregnancy is particularly consequential (*22*–*24*).

Recent research also links police killings to more proximate causes of poor birth outcomes. For example, Bor et al. show that police killings negatively impact mental health among Black Americans (*18*). Related work documents the effect of police killings and aggressive forms of policing on educational outcomes of Black youth with stress and other health consequences as key candidate mechanism (*25*, *26*). This research suggests that police killings can increase stress and other pregnancy risk factors with the potential to harm infant health among Black women living nearby particularly when the killing is perceived as unjustified.

To examine the potential impact of police killings on infant health, this study presents a population-level analysis of vital statistics records from about 3.9 million births in California between 2007 and 2016 linked to incident-level data on 1,891 police killings in California between 2005 and 2017 including 164 cases involving unarmed Black victims (see Supplementary Text for details on the data). The detailed geographic information on mothers' residential location makes it possible to study the effect of police killings during pregnancy in the residential environment on infant health. The analysis restricts the sample to singleton, in-state births to California residents and exclude cases with missing information on key variables. Restricting the sample to singleton births is important considering that twins and other multiples have lower birth weight and worse health at birth. Table S1 includes summary statistics for the sample of births.

Estimating the effect of police killings on infant health is challenging because police killings are not random. They are linked to crime and other neighborhood characteristics, which might also affect birth outcomes. To overcome this challenge, this study relies on a preregistered, Difference-in-Difference (DD) approach with and without sibling comparison (*27*–*29*). The DD approach compares changes in birth outcomes for Black infants in exposed areas born in different time periods before and after police killings of armed and unarmed Blacks to changes in birth outcomes for control cases in unaffected areas. The analysis distinguishes nine time period for mothers who are exposed 18-13, 12-7 and 6-1 months before pregnancy, those who are exposed during the first, second and third trimester in utero, and those who are exposed 1-6, 7-12 and 13-18 months after birth. To safeguard the analysis against additional types of bias, this article uses a second estimation strategy based on mother fixed effects. This approach adjusts for all time-constant, observed and unobserved maternal characteristics. It compares the infant health of siblings who were and were not exposed to police killings during pregnancy. To examine the role of spatial distance from police killings for the effect on infant health, this study defines exposure to police killings by increasing 500-meter intervals ranging from 1km to 6km.[1]

The analysis focuses on two common measures of infant health. The first is birth weight measured in grams, and the second is gestational age measured in weeks based on the obstetric estimate of gestation. Birth weight and gestational age are related to infant mortality (*30*–*33*) and long-term outcomes such as cognitive development, test scores, ADHD and others (*11*, *12*). In addition, the supplementary materials present results for high risk infants and examine binary indicators for low birth weight (<2,500 grams) and preterm delivery (<37 completed weeks of gestation). The materials and methods section in the Supplementary Materials includes additional details about the statistical analysis, variables, and sample. Both estimation strategies and all outcomes were preregistered prior to data access. The preregistered analysis plan is available on the Center for Open Science Achieve at https://osf.io/bthkg/registrations (Note for review process: the online version is embargoed but a blinded copy is attached to the Supplementary Materials).

Figure 1 shows the main findings for the effect of maternal exposure to police killings of unarmed Blacks during pregnancy on the birth weight of Black infants by trimester of exposure and distance to the incident. In-utero exposure to police killings of unarmed Blacks within 1 kilometer of mother's residence substantially reduces the birth weight of Black infants by 50 to over 80 grams depending on the model specification and trimester of exposure. The size of this effect is substantial for exposure during the first and second trimester corresponding to between 0.10 to 0.15 standard deviations (sample standard deviations is 540.5 grams) or a third to a fifth of the Black-White gap in birth weight (sample gap is 242 grams). The effect of exposure during the third trimester, however, is small and statistically insignificant, which is in line with previous research showing reduced effects of stressors at later stages of fetal development (*22*, *23*). The size of the effect is spatially limited and decreases with distance from the event. It is small and statistically insignificant in both model specifications at around 2.5 km. The negative effect during the first and second trimester provides evidence that police killings of unarmed Blacks significantly decrease the health of unborn Black infants residing nearby.

The causal interpretation of the DD results is based on the assumption that in the absence of police killings, birth outcomes would have been the same for exposed and unexposed infants. Several key findings support this assumption and a causal interpretation of the results. First, the trend in birth outcomes for infants exposed before and after pregnancy should be similar to infants in the control group who are never exposed. The models corroborate this common trend

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[1] The preregistered analysis plan mentions distances as small as 0.25 km. This distance turned out to be infeasible because of the small number of births within this distance particularly for the sibling analysis. Table S4 nonetheless reports the findings for 0.25 and 0.5 km.

assumption with a series of terms that capture the difference in birth outcomes between the control and treatment group before and after pregnancy. Figure 2 presents the results. The findings demonstrate that there was no discernible difference in birth outcomes for infants exposed to police killings before or after pregnancy. The difference in birth weight is small for all and statistically insignificant for most of the estimates in both model specifications. However, birth weight is substantially lower for infants exposed to police killings of unarmed Blacks during the first and second trimester of gestation. Figure S2 reports similar results for gestational age. It shows that exposure to police killings of unarmed Blacks during the first and second trimester substantially decreased the gestational age of black infants but not exposure during the other time periods. This temporal pattern is consistent with a causal interpretation of the results.

Second, the findings are consistent across the difference-in-difference model with and without sibling fixed effect term. The sibling model compares differences in birth outcomes for siblings who were and were not exposed to police killings. This additional specification reaffirms the findings based on different assumptions and safeguards the analyses against other types of bias.

Finally, we rule our alternative explanations to better understand the underlying mechanisms by comparing the results across racial/ethnic groups and by examining the impact of police killings of armed Blacks, and armed and unarmed white and Hispanic victims. Police killings of unarmed Blacks can impact the health of Black infants through two main channels: first, by creating stress and anxiety related to perceived injustice and discrimination or fear of future police encounters for themselves, their family members or their unborn child (*18*, *19*); and second, by provoking fear about general violence and crime as threats to personal safety (*22*). Suppose the effect of police killings of unarmed Blacks is based on stress related to perceived discrimination. In this case, the effect should be more pronounced for police killings involving unarmed Blacks and restricted to Black infants (*18*, *19*). However, if the effect is largely driven by general violence and crime, we would expect similar effects for other racial/ethnic groups independent of the victim's race, and potentially larger effects for police killings of armed victims, which signify serious criminal activity. Figure 3 presents the results for birth weight and Figure S3-S5 for the other outcome variables. The results show the effect of police killings of unarmed and armed Black, white and Hispanic victims on the birth weight of Black, white and Hispanic infants within 1.5 km of the incident. The findings indicate that the effect of unarmed Backs is restricted to Black infants. There is no discernible effect for police killings of armed Blacks or unarmed and armed white and Hispanics on any racial group. The effect sizes are mostly small, inconsistent across the two model specifications and statistically insignificant for almost all of the estimated effects. The findings show no systematic pattern related to the timing of exposure. This finding indicates that the effect is race-specific and driven by perceptions of discrimination and structural racism instead of general threats of crime and violence. It rules out many alternative explanations such as violent crime or other confounders that operate similarly for police killings of unarmed and armed Blacks.

The supplementary materials present a number of additional sensitivity analysis and robustness checks that were not specified in the pre-analysis plan. These checks include different definitions of trimesters (Tab. S5), redefining the time periods for exposure before and after pregnancy to cover 3 instead of 6 months (Tab. S6), and addressing post-treatment selection bias related to residential mobility, miscarriage and abortion (Supplementary Text). The results confirm the main conclusions discussed here.

The results provide causal evidence suggesting that extreme forms of police violence have broader consequences and spillover effects on the health of newborn infants. In utero exposure to police killings of unarmed Blacks in the residential environment markedly reduced the health of Black infants but not for other groups. In fact, exposure to a single police killing of an unarmed Black individual during pregnancy accounts for as much as a third of the Black-white gap in birth weight. This finding indicates that police violence is an environmental stressor that contributes to the stark and enduring Black-white disparities in infant health and therefore the intergenerational transmission of disadvantage at the earliest stages of life. Indeed, birth weight and gestational age are not only related to infant death in the short term (*30–33*); the consequences are long-term with implications for cognitive development, test scores, ADHD and others (*11*, *12*).

These findings have important implications for public policy. They highlight the broader implications and social costs of police use of fatal force far beyond the victim and their family members. Understanding the effects environmental stressors such as police violence have on infant health is important for the design and implementation of interventions that attempt to mitigate the negative consequences, reduce disparities in infant health and early child development, and promote a culture of health. In the past, public health initiatives to reduce disparities in infant health have centered on expanding access to prenatal care. The results and other recent research encourage policy makers and public health officials to broadly consider the stress, trauma and anxiety experienced by racial/ethnic minorities such as the adverse consequences of police violence.

The study also has important research implications. Racism is an crucial reason for adverse health outcomes and racial/ethnic disparities in health, but researchers largely rely on cross-sectional studies and struggle to identify the underlying processes that contribute to the observed relations (*17*). By estimating the effect of police killings on birth outcomes, this study highlights a mechanism by which the criminal justice system adversely affects disparities in health. Linking vital records with incident-level event data showcases an innovative approach to study the health consequences of acute environmental stressors. This approach encourages future studies based on vital records, medical claims data or other administrative health records to examine the impacts of an array of events on population health including the persisting Black-white disparities in infant health.

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Author contributions: J. Legewie formulated the theory and predictions, developed the research design, acquired access to the data, conducted the analysis, interpreted the results and wrote the article.

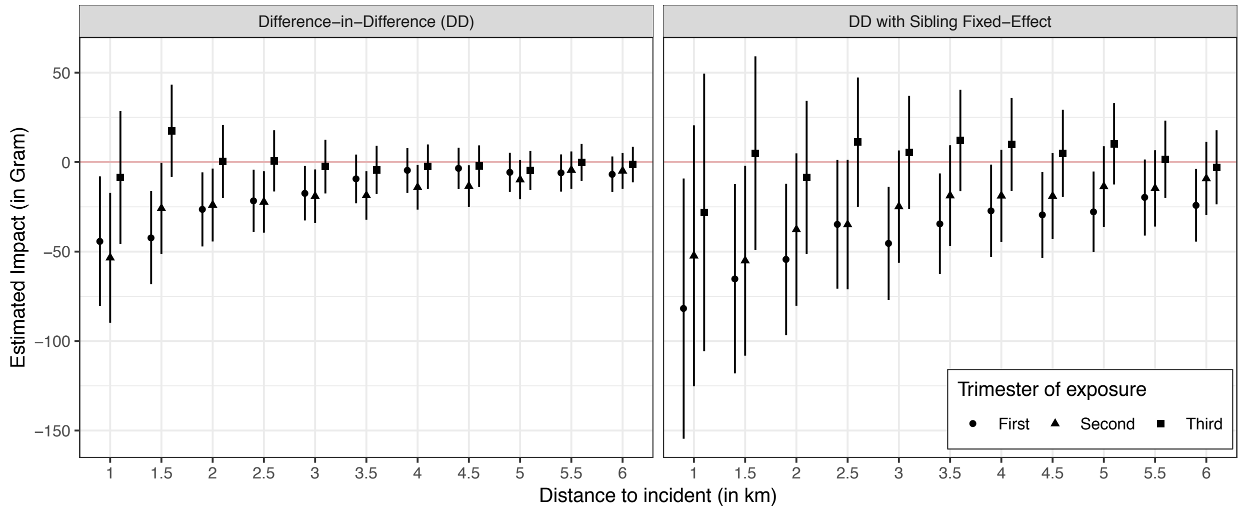

Fig. 1. Effect of maternal exposure to police killings of unarmed Blacks during pregnancy on the birth weight of Black infants by trimester of exposure and distance to the incident. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model (left) and a Difference-in-Difference model with sibling fixed-effects (right). The treatment indicator measures exposure to police killings by trimester of age. Additional covariates for exposure before and after pregnancy are omitted from the graphical presentation. Control variables include a linear county-specific trend, child's gender, mother's age and education, child parity and fixed effect terms for census tract, year-month and mother id for the sibling model. The number of cases is 246,018 for the Difference-in-Difference model and 196,211 for the sibling model.

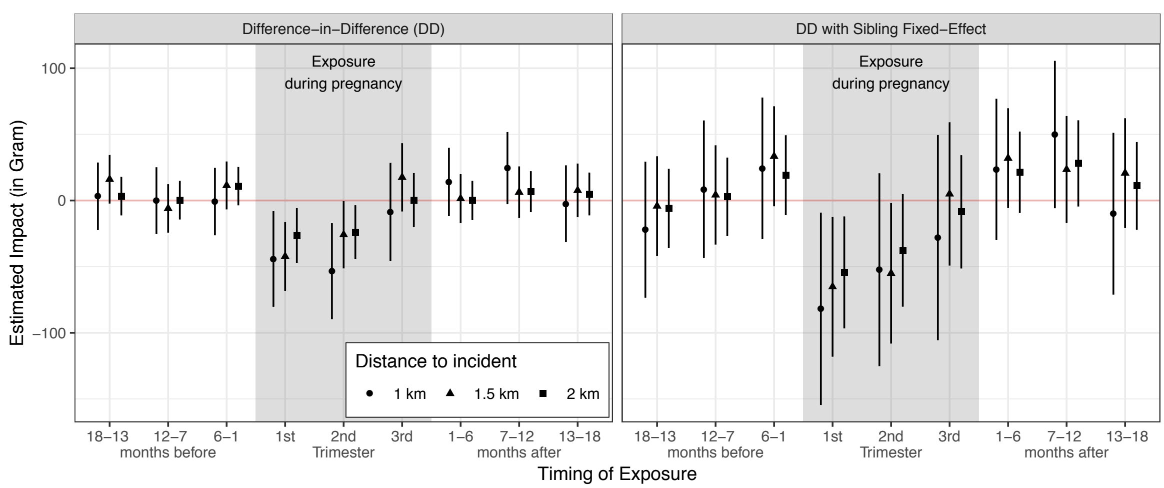

Fig. 2. Effect of maternal exposure to police killings of unarmed Blacks before, during and after pregnancy on the birth weight of Black infants. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model (left) and a Difference-in-Difference model with sibling fixed-effects (right). See note for figure 1 about additional control variables. The number of cases is 246,018 for the Difference-in-Difference model and 196,211 for the sibling model.

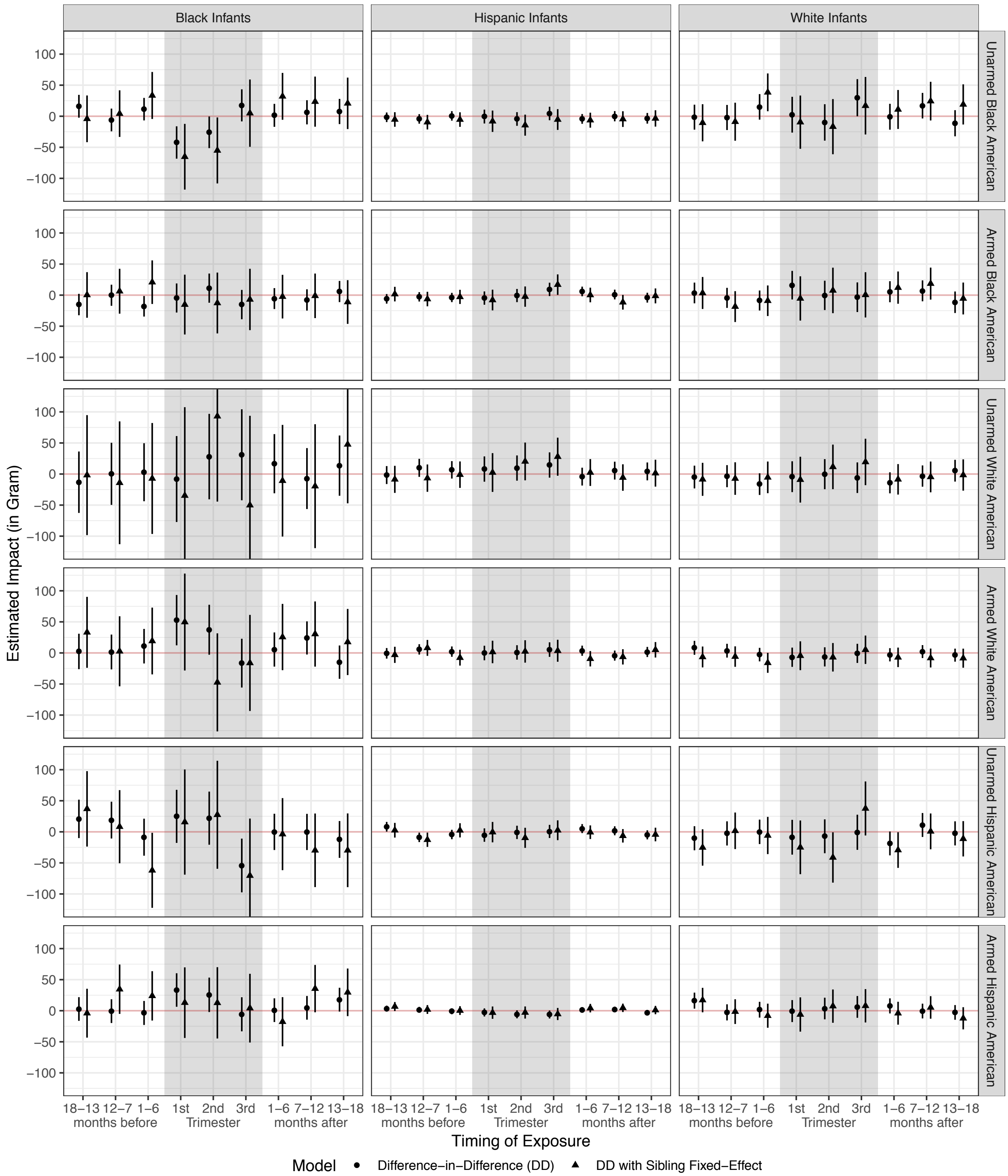

Fig. 3. Effect of maternal exposure to police killings of unarmed and armed Blacks, Whites and Hispanics before, during and after pregnancy on the birth weight of Black, White and Hispanic infants. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model and a Difference-in-Difference model with mother fixed-effects. Confidence intervals for estimates with high uncertainty are cutoff to limit the scale of the y-axis. The number of cases for the DD model is 246,018 for Black infants, 2,392,103 for Hispanic

infants and 1,297,071 for white infants. The number of cases is for the DD model with sibling fixed effect is 196,211 for Black infants, 2,196,409 for Hispanic infants and 1,241,755 for white infants. The full regression table are reported in Table S2-S3.

Supplementary Materials:

Materials and Methods

Supplementary Text

Tables S1-S8

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Preregistered Analysis Plan

Supplementary Materials for
Police Violence and the Health of Black Infants

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Contents

Materials and Methods

Data

This study relies on two data sources. The first are birth certificates for all births in California from 2007 to 2016 assembled by the Center for Health Statistics and Informatics at the California Department of Public Health. These birth records include every birth in California (about half a million per year) with information about birth weight and gestational age at birth as key measures of infant health, the date of birth, exact information on mothers' residential location, and key maternal demographic characteristics such as race and ethnicity. For the geocoding of addresses on birth records, the ArcGIS Desktop geocoder was used. To identify full siblings in the sample, the study followed the procedure used by Liu, King, and Bearman (*1*) based on California birth records from 1997 to 2007. This procedure exact matches mother's date of birth, father's date of birth, and the first letter of the mother's maiden name for all children born between 2007 and 2016. The analysis restricts the sample to singleton births considering that twins and other multiples have lower birth weight and worse health at birth. All analysis excludes cases with missing information on birth date, birth weight, gestation age, mother's race or mother's residential address.

The second data source is incident-level data on policing killings in California between 2005 and 2017. This data relies on Fatal Encounters (*2*) and extensive additional coding. The coding procedure is described in detail below. The result of this procedure is a comprehensive database on officer-involved killings in California between January 2005 and December 2017. The database includes information on the date and geographic location of the incident, the race and age of the victim and whether the victim was armed or unarmed.

Outcome Variables

The analysis focuses on two common measures of infant health. The first is birth weight measured in grams, and the second is gestational age measured in weeks based on the obstetric estimate of gestation. Birth weight and gestational age are related to infant mortality (*1–3*)(*3–6*) and long-term outcomes such as cognitive development, test scores, ADHD and others (*7*, *8*). The measurement of birth weight is comparatively accurate, whereas gestational age is less reliable considering that it relies on the correct determination of the last menstrual period (LMP). The obstetric estimate of gestational age introduced by the National Centers for Health Statistics (NCHS) in 2003 and reported on California birth certificates starting in 2007, somewhat improves the measurement quality compared to previous estimates even though concerns persist (*9*, *10*). For this reason, the main text largely focuses on the findings for birth weight. The results for gestational age are reported in the supplementary materials even though the likely biological mechanism affects gestational age and preterm birth (*11*). In addition, the supplementary materials present results for high risk infants and examine binary indicators for low birth weight (<2,500 grams) and preterm delivery (<37 completed weeks of gestation).

Summary Statistics

Table S1 presents summary statistics for the variables used in our main analysis for all births and separately for infants exposed to police killings during the first, second or third trimester within 3 kilometers by victim characteristics. Infants exposed to police killings of armed or unarmed Blacks have on average lower birth weight, a higher rate of premature births and the proportion of Black infants is substantially higher compared to all births.

Statistical Analysis

The goal of the analysis is to estimate the effect of maternal exposure to police killings of unarmed Blacks on birth outcomes for Black infants. Estimating the effect of police killings is challenging because police killings are not random. They are linked to crime and other neighborhood characteristics, which might also affect birth outcomes. To overcome this challenge, this study relies on a Difference-in-Difference (DD) approach with and without sibling comparison (*12–14*). The estimation strategy and model specification are motivated by previous research on the effect of Hydraulic fracturing on infant health (*14*), and the effect of police killings (*15*) and police surges (*16*) on student test scores.

All models were estimated using a generalization of the within (fixed-effect) estimator for multiple high dimensional categorical variables based on the lfe package in R (*17*). In particular, the models used the within transformation for the neighborhood and year-by-month fixed-effect term and for the mother fixed effect term in the model with sibling comparison.

Difference-in-Difference model

The difference-in-difference approach leverages millions of birth records from California to compare changes in birth outcomes for Black infants in exposed areas born in different time periods before and after police killings of Blacks to changes in birth outcomes for control cases in unaffected areas. In particular, the models distinguish nine time period for children exposed to a police killing 18-13, 12-7 and 6-1 months before pregnancy, those who are exposed during pregnancy by first, second and third trimester, and those who are exposed 1-6, 7-12 and 13-18 months after pregnancy. The regression models use clustered standard errors on the neighborhood level to address potential serial correlation problems (*18*). Formally, the models are specified as

$$y_{icjt} = \pi_{cj} + \eta_t + \gamma_c year + \beta_1 Near_i + \sum_{r=-3}^{5} \delta_r Exposure_{i,r} + \boldsymbol{\beta_2 X}_{icjt} + \varepsilon_{icjt}$$

where the dependent variables are birth outcomes for mother *i* in county *c* in census tract *j* and at year-by-month time period *t* (e.g. January 2014). The model includes a stable neighborhood effect π_{cj} that controls for mean differences in birth outcomes across census tracts, and a year-by-month time effect η_t that captures differences in birth outcomes over years and months (e.g. January 2014) that are constant across all births such as seasonal fluctuations or general time trends. In addition, the model includes county-specific, linear time trends $\gamma_c year$ that captures different temporal trends in birth outcomes across California's 58 counties. The vector $\boldsymbol{X}_{ijt}$ consists of maternal and child characteristics. It includes sex of child coded as 0 for male and 1 for female, mother's age (categorized as less than 20, 20–29, 30–34, or 35 years or older), mother's education (categorized as less than high school, high school, some college, college, advanced degree, or missing), and child parity (first, second, third, fourth born or higher, parity missing).

To estimate the effect of maternal exposure to police killings, the model includes two terms constructed separately for police killings of armed and unarmed Blacks. The first is an indicator variable $Near_i$ that measures proximity of mother's residence at time of birth to any police killing of unarmed Blacks between 2005 and 2017 independent of the timing of the birth and the incident. It is coded as 1 if any police killing occurred within a specific distance *k* and 0 otherwise regardless of when the incident occurred. There is no a priori or theoretical way to derive the correct value of the distance parameter *k*. Instead, the spatial scale of a potential effect is an empirical question. Hence, the analysis defines exposure to police killings by increasing 500 meter intervals ranging from 1km to 6km.[1] The $Near_i$ indicator measures whether at least one police killing occurred within the relevant distance.

The second is a set of 9 indicator variables that measures the timing of maternal exposure to police killings of armed/unarmed Blacks within a specific distance k. The 9 indicators distinguish between incidents that happened in different time period before pregnancy, exposure during pregnancy by trimester of gestation (the key treatment indicators) and exposure during different time periods after pregnancy. All 9 indicator variables are binary and coded as 1 if at least one police killing occurred during the specific time interval and within k kilometers of mother's residence and 0 otherwise. Multiple of the 9 indicator variables can be coded as 1 if multiple police killings occurred within k kilometer.

The three indicators for exposure before pregnancy are the time periods 18 to 13, 12 to 7 and 6 to 1 months before pregnancy. They are designated as D_j where j ranges from -3 to -1. While birth outcomes might be affected by exposure to police killings prior to pregnancy, infants are not exposed in utero. Previous research and the most plausible mechanism linking maternal stress to birth outcomes suggest that the effect should be small.

The three treatment indicators measure exposure in utero by trimester of gestation within k kilometers of mother's residence. They are defined as exposure during the 1st trimester D_0, 2nd trimester D_1 and 3rd trimester D_2 of gestation. The three terms are the key treatment indicator and estimate the effect of maternal exposure to police killings by trimester of gestation. Trimesters are defined as consecutive 12 weeks intervals prior to the date of birth. This definition deviates from the medical definition based on the last

[1] The preregistered analysis plan includes distances as small as 0.25km. This distance turned out to be infeasible because of the small number of births within this distance. Following the pre-analysis plan, the supplementary material nonetheless reports the effect for 0.25 and 0.5 km in Table S4.

menstrual period (LMP). It ensures that the lengths of the third trimester and therefore the likelihood of exposure to police killings does not depend on gestational age introducing a mechanical correlation between the treatment and outcome in the data. Table S5 shows the results from supplementary analyses exploring the sensitivity of the results to different definitions of trimesters. It includes an instrumental variable model using LMP-based trimesters for the three treatment indicators instrumented by exposure based on consecutive 12 weeks intervals used in the main analysis. Note that the pre-analysis plan only refers to "trimesters" without specifying the coding of the time periods and without anticipating the problem related to the mechanical correlation between the treatment and outcome. The sensitivity analysis in Table S5 ensures the robustness of the results to different definitions of trimesters.

The final three terms are defined as exposed 1 to 6, 7 to 12 or 13 to 18 months after birth within *k* kilometers of the incident. The effect of the three indicators should be zero because the incident occurred after birth. The terms help us to evaluate the plausibility of the design. This specification makes it possible to examine changes in birth outcomes of Black infants before and after police killings of unarmed Blacks.

The second step of the analysis compares the estimates for maternal exposure to police killings of unarmed Blacks with similar estimates for killings of armed Blacks and unarmed and armed white and Hispanic victims on the health of Black, white and Hispanic infants. These analyses are based on separate exposure indicators for police killings involving Black, white and Hispanic victims and estimate the models separately for the sample of Black, white and Hispanic infants.

The core assumption of the DD approach is that in the absence of police killings changes in birth outcomes of exposed children would have been the same as changes in birth outcomes of children in control areas (common trend assumption). The estimates δ_r for exposure before ($r< 0$) and after ($r> 2$) pregnancy make it possible to evaluate the common trend assumption indirectly. However, time-specific, neighborhood-level factors that are related to police killings and birth outcomes still threaten the identification strategy. Most importantly, unobserved trends in crime rates or policing may account for both police shootings and changes in birth outcomes. From this perspective, a potential effect on birth outcomes is not caused by exposure to officer-involved killings but instead by changes in crime rates that increase police activity and officer-involved killings. While the model accounts for county-specific linear trends in birth outcomes and the specification of the exposure variable focuses on the nine months of pregnancy, local crime waves (as opposed to general trends) that coincide with police killings are a potential threat to the identification strategy particularly because previous research links crime with birth outcomes (*19*)(*19*). To address this concern, we implement a second estimation strategy based on a sibling comparison.

Sibling comparison

The second model uses a mother fixed effects term to compare differences in birth outcomes for siblings who were and were not exposed to police killings. It is based on the following specification

$$y_{icjt} = \alpha_i + \pi_{cj} + \eta_t + \gamma_c year + \beta_1 Near_i + \sum_{r=-3}^{5} \delta_r Exposure_{i,r} + \boldsymbol{\beta_2 X}_{icjt} + \varepsilon_{icjt}$$

The mother fixed effect term α_i accounts for all observed and unobserved characteristics of the mother that are constant over time. As a consequence, the vector of covariates now only includes child's sex and excludes all characteristics that are constant or almost constant over time.

This additional specification reaffirms the findings based on different assumptions and safeguards our analyses against other types of bias. In addition, the analysis compares the effect of maternal exposure to police killings of armed and unarmed Blacks as a falsification test and to rule out alternative explanations. For example, the alternative explanation of a potential effect based on crime as a confounder has opposite implications for the types of police killings that are particularly consequential. If police killings affect birth outcomes simply because they reflect larger patterns in crime or because they provoke fear about crime and violence in general, the effect of police killings involving armed victims should be more pronounced and the effect should be similar across racial/ethnic groups. However, if the effect is based on stress related to perceived discrimination, the effect should be more pronounced for police killings involving unarmed Blacks and it should be restricted to Black infants. The analysis exploits these contradicting implications to rule out crime and many other potential confounders as alternative explanations. In particular, it compares the effect of maternal exposure for incidents involving armed and unarmed suspect as a measure of the threat posed by suspects.

Supplementary Text

Police Homicides in California, 2005-2017

This project uses incident-level data on all policing killings in California between 2005 and 2017. To collect comprehensive information on police killings, this study relied on Fatal Encounters with extensive additional coding to fill in missing information, correct errors and add additional variables to the database. The goal of Fatal Encounters is to "create a comprehensive national data-base of people who are killed through interactions with police" from 2000 to today (*2*). It is the most comprehensive data collection project that tracks officer-involved killings over multiple years. The Fatal Encounters archive relies on paid researchers, public records requests and crowd-sourced data. As of September 2018, the archive considers the information complete from January 2005 to December 2017.

First, FE data was downloaded on April 8, 2018. The raw database includes 3,022 incidents in California between 2005 and 2017.

Second, paid researchers coded the type of incident in order to restrict the cases to "intentional or purposeful police killing" and "unintentional police killing but result of extremely reckless, reckless or negligent use of force". This coding is based on the following definition of police killings as

> "any interaction with the police where the officer uses force and the person dies during or immediately after the interaction. This includes cases that result in death as a consequence of being shot, beaten, restrained, pepper sprayed, tasered, or otherwise harmed by police officers, whether on-duty or off-duty. … This includes acts where one or more police officers set in motion a chain of events that leads to the death of a suspect or another individual if the original act involved the use of police force. These cases might capture high speed chases or instances where a police officer kills a bystander when shooting at a suspect. The definition excludes (a) suicides, (b) accidents caused by suspects themselves (e.g. a fleeing suspect who causes a deadly car crash), and (c) police-caused accidents unrelated to the use of force (e.g. a car crash under normal traffic conditions that is not related to the vehicular pursuit of a suspect)."

Out of the 3,022 cases in the Fatal Encounters database, 2,025 cases were classified as "Intentional or purposeful" or "Unintentional but result of extremely reckless, reckless or negligent use of force". The remaining cases were excluded from the database. Excluded cases include duplicates, an incident in which an off-duty police officer shot and killed his wife during a domestic dispute, a case in which a suspect successfully fled to a forest area from the police and was found dead several days later from drowning in a nearby swamp, several cases in which the suspect kills bystanders during a car chase, and several cases in which the deaths are accidental or self-inflicted. The analysis further restricts police killings to 1,891 incidents involving Black, Hispanic or white victims.

Third, the coding procedure verified and completed missing information for individual victims on the following variables: victim's race, date and geographic location of the incident. As part of this verification process, coders added a variable "armed/unarmed" to the database. While the Fatal Encounters database is comprehensive and well-maintained, there are occasional errors and cases with missing information. Most important, information on victim race is missing for about 17.4% of all cases in California and considered unreliable for others. To address this problem, this study used two independent coders from Amazon Mechanical Turk to verify and complete the information for all cases. Each coder received the victim's name, date of the incident, and the state in which it occurred. They were asked to collect information on the race of the victim, the involved police agencies, and the city in which the incident occurred from newspaper sources. A student research assistant cross-validated all cases for which the information from Fatal Encounters and our MTurk coders were not identical. This cross-validation and the comparison between the two independent coders strengthens the quality and accuracy of the data verification process.

Finally, this study used the Google Geocoding API to convert the address of the incident into geographic coordinates (latitude and longitude).

The result of this procedure is a comprehensive database of all officer-involved killings in California between January 2005 and December 2017. Figure S1 shows the geographic distribution of police killings in California from 2005 to 2017 by race. Police killings are concentrated in urban centers like Los Angeles, San Diego and Fresno but many cases are spread throughout the state across 50 of the 58 counties in California. Most police killings involve Black (21%), white (34%) or Hispanic (45%) victims. Over 30% involve unarmed victims.

Post-Treatment Selection Bias

Conditioning on posttreatment variables either by controlling for, or by sub-setting data based on variables measured after the treatment can bias estimates of causal effects (*20*, *21*). This post-treatment selection bias is a potential concern for the results presented here.

Cases might select out of the treatment group or California birth records entirely for two key reasons: residential mobility or early termination of pregnancy through miscarriages and abortions. If this selection is related to the treatment indicator "exposure to police killings", the results presented here might be biased. For example, a family might decide to move after a local policing killing. Because birth records only include the residential address at birth, this selective mobility leads to measurement error in the treatment indicator. Similarly, stress related to local police killings might induce miscarriages or influence decisions about abortions so that pregnant women who are exposed to the treatment select out of the sample. This section discusses both potential biases in detail, presents supporting evidence, and sensitivity analysis to address the concern.

Residential Mobility

Parents might decide to move after a local policing killing. Because birth records only include the residential address at birth, this selective mobility leads to measurement error in the treatment indicator. Previous research suggests that 12% of subjects move at least once during pregnancy with most moves within the same neighborhood and over short distances (*22*). However, it remains unclear whether residential mobility during pregnancy is related to local police killings. Two additional analyses address this potential problem. Both analyses use data on siblings to take advantage of at least two recorded addresses for the first and second child. The analyses focus on exposure to police killings of unarmed Blacks among Black mothers as the subgroup most affected by local police killings.

The first analysis examines whether exposure to police killings effects residential mobility. For this purpose, the sample is restricted to siblings and the level of analysis is a sibling pair. The outcome is defined as change in census tract between the first and second child. The treatment indicator is defined as exposure to police killing of unarmed

Blacks during pregnancy with the second child *based on the address from the first birth*. The results are presented in Table S7. They show the effect of exposure to police killing of unarmed Blacks during pregnancy on residential mobility for Black infants by distance to the incident (1, 2 and 3km) and for two model specification without the control variables used in the main model and with the same set of control variables. In addition, the models include a variable that measures the age difference between the first and second child in years. The results show no discernable effect of exposure to police killings of unarmed Blacks on residential mobility. The effect estimates are small and statistically insignificant with inconsistent signs across model specifications. This finding indicates that local police killings are unrelated to residential mobility during pregnancy alleviating concerns about post-treatment selection bias.

The second sensitivity analysis uses an instrumental variable approach to correct for measurement error in the treatment indicator (*22*). Replicating the sibling analysis from the main text, the analysis instruments the treatment indicators for exposure during the first, second and third trimester (as well as the terms for exposure before and after pregnancy) with exposure to police killings based on the residential address from the birth record of the first-born child. For older siblings, this instrumental variable is unaffected by any measurement error introduced through residential mobility. The model includes the same set of control variables and fixed effect terms for mother, census tract and year-month as the main sibling analysis. Results from the first stage regression show that the instruments are highly correlated with the treatment indicator with partial F-statistics well above 10,000 ($p < 0.000$), which is far higher than the commonly used threshold of 10. Table S8 presents the results from the two-stage least squares (2SLS), instrumental variable regression together with the same results presented in the main text of the article. The findings are remarkably consistent across the sibling model presented in the main text and the 2SLS sibling model using instruments based on the residential address from the first-born birth record. This finding suggests that post-treatment bias related to residential mobility or residential mobility in general is not a concern for the findings presented here.

Miscarriage and Abortions

The second potential post-treatment selection bias is based on early terminations of pregnancy through miscarriage or induced abortion, which are not recorded in birth records. In 2011, only 67% percent of pregnancies resulted in live births and are therefore recorded in birth records (*23*). Of the remaining pregnancies, 18% resulted in abortions and 15% ended in miscarriage (*23*). Stress related to local police killings might increase the likelihood of miscarriages or influence decisions about abortions so that pregnant women who are exposed to the treatment select out of the sample. This sub-setting of the data based on post-treatment events amounts to potential post-treatment selection bias.

Miscarriages are defined as the loss of a pregnancy before the 20th week (*24*, *25*). Most miscarriages happen in early pregnancy before the 12th week and occur because of abnormal genes or chromosomes, maternal health conditions such as diabetes, infections, hormonal problems or other conditions (*25*). The most common causes of miscarriage make it unlikely that exposure to police killings in the residential environment and related stress are a major cause of miscarriage. However, a third of pregnancy losses are not linked to chromosomal abnormalities (*25*) and recent research has established some evidence about the link between miscarriage and high levels of stress often related to recent negative life events even though the evidence is based on cross-sectional studies and not necessarily causal (*26*). Accordingly, miscarriage remains a concern for post-treatment selection bias – albeit small.

Induced abortions, in contrast, are intentional terminations of pregnancy mostly during the first trimester of pregnancy. While a significant proportion of pregnancies end in abortions, systematic reviews of research on reasons why women have induced abortions give no indication that exposure to local police killings or more generally stressful events play a role in the decision making process (*27*, *28*). Instead, research indicates that most abortions are motivated by personnel or partner-related reasons such as wrong timing for career, material reasons related to income and housing, or medical reasons.

Because birth records lack data on miscarriage or abortions, there is no clear statistical solution to diagnose and remedy the potential problem (*20*). However, estimating the effect of police killings on the number of births instead of birth outcomes shows no discernable change in fertility in the year after police killings. This finding is in line with previous research that shows exposure to homicides in general does not influence fertility (*19*). It supports the argument that police killings are unrelated to miscarriages, abortions and fertility more broadly. In addition, miscarriage and abortions almost exclusively affect early pregnancy and therefore exposure during the first trimester. The findings, however, also provide evidence for an effect of exposure during the second trimester, which should be free of any concerns about post-treatment selection bias related to early terminations of pregnancy. Finally, any sample attrition related to miscarriage and abortion arguably implies that the results presented in the main text underestimate the negative effect of police killings of unarmed Blacks on infant health. Local police killings presumably only (if at all) influence miscarriage and abortion for pregnant women who are most severely affected by exposure to police killings. This sample attrition of observations strongly affected by the treatment would suggest that the estimates represent lower-bound estimates of the causal effect.

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Tables S1 to S8

Table S1. Sample characteristics. The sample is defined by all singleton, in-state births to California residents and excludes cases with missing information on key variables. The descriptive statistics for infants exposed during pregnancy by victim characteristics combine Black, white and Hispanic infants.

		Exposed to police killing during pregnancy within 3 km by victim characteristics					
	All	Unarmed			Armed		
	Births	Black	White	Hisp.	Black	White	Hisp.
Births	3,935,192	132,503	48,560	127,082	156,784	142,052	329,310
Birth Outcomes							
Birth weight (grams)	3,347.6	3,285.2	3,345.2	3,311.0	3,297.1	3,341.9	3,304.7
Gestational age (weeks)	38.7	38.6	38.8	38.6	38.6	38.8	38.6
Low birth weight	5.0%	6.3%	4.9%	5.6%	6.0%	5.1%	5.7%
Premature birth	7.0%	8.2%	6.7%	7.6%	8.0%	7.0%	7.6%
Maternal characteristics							
Average Age	28.2	27.1	28.4	27.4	27.5	28.2	27.4
Education							
Less than high school	24.1%	39.3%	24.6%	34.1%	34.8%	24.9%	36.4%
High school	27.5%	28.9%	26.3%	31.0%	29.3%	27.4%	30.5%
Some college	25.1%	19.6%	24.1%	21.9%	20.7%	24.1%	21.1%
Bachelor's degree	14.1%	6.6%	14.8%	7.5%	8.3%	13.7%	7.0%
Advanced degree	7.2%	3.6%	8.0%	3.6%	4.9%	7.6%	3.2%
Missing	2.1%	2.1%	2.2%	1.9%	2.0%	2.1%	1.9%
Percent White	33.0%	10.6%	35.6%	12.5%	14.4%	33.1%	11.6%
Percent Black	6.3%	16.5%	6.2%	7.0%	16.8%	6.8%	6.3%
Percent Hispanic	60.8%	72.9%	58.1%	80.4%	68.8%	60.1%	82.1%

Table S2. Results from 36 Difference-in-Difference models (one per row) for the effect of exposure to police killing on birth weight by victim characteristics, infant race and distance to event. Control variables include a linear county-specific trend, child's gender, mother's age and education, child parity, proximity to any police killing and fixed effect terms for census tract, and year-month. The number of cases is 246,018 for Black infants, 2,392,103 for Hispanic infants and 1,297,071 for white infants. *P < 0.05, **P < 0.01, ***P < 0.001

			Exposed before pregnancy			Exposed during pregnancy			Exposed after birth		
Victim	Infant Race	Distance	13-18 months	7-12 months	1-6 months	1st trimester	2nd trimester	3rd trimester	1-6 months	7-12 months	13-18 months
Unarmed Black	Black	1 km	3.29	-0.18	-0.78	-44.14*	-53.43**	-8.58	14.01	24.45	-2.50
			(12.98)	(12.90)	(13.03)	(18.46)	(18.53)	(18.92)	(13.20)	(13.92)	(14.83)
		1.5 km	16.05	-5.99	11.37	-42.25**	-25.85*	17.50	1.43	6.32	7.64
			(9.37)	(9.33)	(9.24)	(13.28)	(13.00)	(13.16)	(9.43)	(9.92)	(10.35)
	Hispanic	1 km	1.97	0.20	1.14	5.21	3.88	4.41	-3.28	0.27	2.03
			(5.58)	(5.58)	(5.55)	(8.16)	(8.04)	(7.93)	(5.73)	(5.96)	(6.24)
		1.5 km	-1.68	-4.33	0.54	-0.53	-4.44	4.39	-4.30	0.03	-3.32
			(3.93)	(3.92)	(3.91)	(5.68)	(5.60)	(5.52)	(4.01)	(4.20)	(4.37)
	White	1 km	9.97	-22.25	24.43	-16.13	0.53	51.91*	-13.96	12.04	1.09
			(14.73)	(14.90)	(15.19)	(20.66)	(21.62)	(22.75)	(15.17)	(14.95)	(15.41)
		1.5 km	-1.52	-2.03	15.07	2.46	-9.97	29.84	-0.80	16.98	-11.28
			(10.25)	(10.31)	(10.49)	(14.69)	(14.95)	(15.23)	(10.62)	(10.49)	(10.74)
Armed Black	Black	1 km	-11.13	-2.15	-19.38	3.43	14.97	-9.98	-12.27	7.40	5.18
			(12.21)	(12.07)	(11.85)	(16.96)	(17.28)	(17.23)	(12.09)	(12.06)	(12.09)
		1.5 km	-15.14	-0.19	-17.94*	-4.61	11.26	-15.21	-5.55	-7.75	5.81
			(8.79)	(8.66)	(8.44)	(11.94)	(11.97)	(12.04)	(8.60)	(8.73)	(8.68)
	Hispanic	1 km	-7.49	-9.29	-5.38	-6.52	-0.10	10.57	8.02	6.66	-2.81
			(5.58)	(5.49)	(5.39)	(7.79)	(7.75)	(7.77)	(5.60)	(5.68)	(5.75)

		1.5 km	-5.98	-2.74	-3.79	-4.75	-0.65	9.27	5.92	0.98	-4.09
			(3.93)	(3.86)	(3.80)	(5.45)	(5.41)	(5.48)	(3.97)	(4.01)	(4.04)
	White	1 km	-18.72	-4.16	-10.42	16.82	20.62	10.46	-5.35	-2.78	-21.92
			(12.22)	(11.81)	(11.73)	(16.93)	(17.31)	(17.10)	(12.37)	(12.27)	(12.78)
		1.5 km	3.49	-4.40	-8.64	16.01	-0.38	-3.36	5.48	6.91	-11.45
			(8.50)	(8.23)	(8.21)	(11.74)	(12.04)	(12.16)	(8.63)	(8.58)	(8.83)
Unarmed White	Black	1 km	-46.71	-24.71	-32.02	31.91	-3.66	53.95	45.23	-43.37	52.12
			(38.11)	(37.13)	(35.64)	(52.49)	(50.12)	(55.02)	(35.03)	(38.36)	(36.11)
		1.5 km	-13.18	0.35	2.90	-8.05	28.06	30.99	16.61	-7.29	13.52
			(25.22)	(25.49)	(23.82)	(35.29)	(35.09)	(37.36)	(24.30)	(25.03)	(24.75)
	Hispanic	1 km	5.78	-6.39	7.72	10.39	6.55	12.46	-2.26	12.78	5.62
			(10.54)	(10.56)	(10.13)	(14.77)	(14.60)	(14.57)	(10.40)	(10.42)	(10.36)
		1.5 km	-1.66	9.95	6.74	8.02	9.62	14.51	-4.16	5.49	4.23
			(7.37)	(7.40)	(7.16)	(10.37)	(10.36)	(10.36)	(7.33)	(7.34)	(7.34)
	White	1 km	-11.74	2.96	-13.08	-22.34	-10.83	5.93	5.86	-2.56	4.39
			(13.62)	(13.02)	(12.68)	(17.83)	(17.40)	(17.72)	(12.44)	(12.44)	(12.73)
		1.5 km	-4.85	-3.43	-16.25	-4.29	-0.21	-5.90	-14.15	-3.26	5.35
			(9.35)	(9.07)	(8.89)	(12.66)	(12.33)	(12.55)	(8.64)	(8.72)	(8.94)
Armed White	Black	1 km	-15.98	-32.30	-9.56	67.42*	17.26	-20.91	-22.70	12.86	-25.49
			(21.11)	(20.71)	(20.90)	(29.89)	(29.60)	(28.87)	(20.50)	(20.05)	(19.54)
		1.5 km	2.39	1.52	10.84	52.74*	37.31	-16.42	5.49	24.12	-14.84
			(14.55)	(14.30)	(14.19)	(20.67)	(20.51)	(20.03)	(14.04)	(13.60)	(13.68)
	Hispanic	1 km	7.52	4.45	3.80	7.86	-5.52	5.46	4.49	-10.00	-2.00
			(6.30)	(6.21)	(6.19)	(8.70)	(8.67)	(8.70)	(6.06)	(6.08)	(6.10)
		1.5 km	-0.67	5.68	2.12	-0.13	0.79	5.39	3.56	-4.27	1.54
			(4.34)	(4.26)	(4.24)	(5.97)	(5.93)	(5.95)	(4.16)	(4.13)	(4.15)
	White	1 km	11.71	-5.19	-0.74	-22.14*	-12.71	-9.29	-1.00	-2.11	-4.24
			(8.19)	(8.01)	(7.97)	(11.21)	(11.31)	(11.18)	(7.81)	(7.57)	(7.64)

		1.5 km	8.22	3.62	-2.72	-6.93	-6.34	-0.69	-2.98	2.16	-3.56
			(5.72)	(5.66)	(5.56)	(7.90)	(7.87)	(7.85)	(5.43)	(5.31)	(5.34)
Unarmed Hispanic	Black	1 km	7.53	6.61	-0.05	61.28	9.54	-45.39	-21.42	21.14	-20.78
			(21.77)	(21.46)	(21.54)	(31.31)	(31.15)	(32.12)	(21.33)	(21.30)	(21.82)
		1.5 km	20.85	18.84	-8.62	24.92	21.99	-54.17*	-0.08	-0.20	-12.26
			(15.77)	(15.11)	(15.20)	(21.80)	(21.82)	(22.06)	(14.89)	(14.86)	(15.13)
	Hispanic	1 km	9.68	-7.68	-2.10	-12.95	-1.62	6.92	1.82	4.86	-2.46
			(5.69)	(5.60)	(5.56)	(7.94)	(7.86)	(7.72)	(5.36)	(5.35)	(5.39)
		1.5 km	8.15*	-8.90*	-4.32	-5.22	-0.90	0.64	5.20	1.64	-4.87
			(3.98)	(3.88)	(3.88)	(5.49)	(5.47)	(5.38)	(3.72)	(3.69)	(3.72)
	White	1 km	-18.71	-6.82	-8.01	-8.26	2.61	0.44	-16.59	-4.93	10.78
			(14.20)	(14.36)	(14.77)	(20.96)	(19.93)	(21.39)	(14.23)	(14.37)	(14.27)
		1.5 km	-10.33	-2.56	-0.03	-8.70	-7.17	-0.72	-18.72	11.01	-2.50
			(9.90)	(9.93)	(10.05)	(14.28)	(13.91)	(14.42)	(9.77)	(9.83)	(9.90)
Armed Hispanic	Black	1 km	-6.39	1.31	-0.74	31.81	16.95	-21.44	22.03	-8.27	-2.39
			(13.75)	(13.92)	(13.79)	(19.31)	(20.24)	(19.92)	(13.67)	(13.69)	(13.77)
		1.5 km	2.76	-0.64	-3.60	33.35*	25.62	-5.74	0.89	4.68	17.78
			(9.73)	(9.75)	(9.85)	(13.76)	(14.14)	(13.99)	(9.74)	(9.73)	(9.78)
	Hispanic	1 km	2.05	5.16	-1.30	-1.63	-4.84	-10.47*	-4.43	1.19	-1.19
			(3.38)	(3.33)	(3.31)	(4.66)	(4.60)	(4.59)	(3.19)	(3.12)	(3.16)
		1.5 km	3.42	1.51	-0.98	-2.75	-5.79	-6.06	1.29	2.19	-3.10
			(2.43)	(2.41)	(2.39)	(3.32)	(3.28)	(3.27)	(2.30)	(2.26)	(2.27)
	White	1 km	17.91	-4.65	11.74	20.45	0.29	7.94	10.28	-1.13	-0.40
			(9.65)	(9.61)	(9.40)	(13.14)	(12.86)	(12.97)	(9.01)	(8.83)	(8.83)
		1.5 km	16.25*	-2.65	1.64	-0.55	3.57	6.14	7.78	-0.51	-2.74
			(6.57)	(6.61)	(6.48)	(9.03)	(8.88)	(8.93)	(6.20)	(6.05)	(6.03)

Table S3. Results from 36 Difference-in-Difference models with sibling fixed-effect (one per row) for effect of exposure to police killing on birth weight by victim characteristics, infant race and distance to event. Control variables include a linear county-specific trend, child's gender, proximity to any police killing and fixed effect terms for census tract, year-month and mother's id. The number of cases is 196,211 for Black infants, 2,196,409 for Hispanic infants and 1,241,755 for white infants. *P < 0.05, **P < 0.01, ***P < 0.001

			Exposed before pregnancy			Exposed during pregnancy			Exposed after birth		
Victim	Infant Race	Distance	13-18 months	7-12 months	1-6 months	1st trimester	2nd trimester	3rd trimester	1-6 months	7-12 months	13-18 months
Unarmed Black	Black	1 km	-22.04	8.48	24.32	-81.86 *	-52.35	-28.11	23.48	49.83	-9.97
			(26.24)	(26.56)	(27.31)	(37.10)	(37.20)	(39.58)	(27.28)	(28.43)	(31.21)
		1.5 km	-4.18	4.21	33.42	-65.21*	-55.07*	4.97	32.01	23.49	20.75
			(19.18)	(19.14)	(19.29)	(26.98)	(27.08)	(27.64)	(19.24)	(20.58)	(21.14)
	Hispanic	1 km	9.64	-3.35	-6.50	2.48	-13.42	4.85	-8.46	-12.16	9.08
			(8.44)	(8.51)	(8.48)	(12.58)	(12.43)	(12.29)	(8.86)	(9.14)	(9.65)
		1.5 km	-5.24	-9.58	-5.37	-8.06	-14.37	-5.32	-6.35	-4.60	-3.55
			(5.97)	(5.99)	(5.96)	(8.76)	(8.64)	(8.53)	(6.16)	(6.45)	(6.71)
	White	1 km	-7.81	-32.59	33.03	-42.37	-47.75	27.00	26.10	43.33	15.08
			(22.07)	(22.98)	(22.76)	(31.55)	(33.51)	(35.60)	(22.49)	(22.40)	(23.65)
		1.5 km	-10.54	-8.85	38.46*	-9.55	-16.77	16.91	10.90	24.32	19.00
			(15.23)	(15.62)	(15.52)	(21.87)	(22.65)	(23.61)	(16.00)	(15.88)	(16.49)
Armed Black	Black	1 km	-8.81	12.81	64.10*	-24.56	-43.03	8.96	-14.66	31.17	9.41
			(25.74)	(25.54)	(25.50)	(35.34)	(36.95)	(35.71)	(25.20)	(25.17)	(24.96)
		1.5 km	0.28	6.29	20.84	-15.21	-12.66	-6.97	-2.44	-1.12	-11.10
			(18.72)	(18.43)	(17.90)	(24.57)	(24.98)	(25.19)	(17.93)	(18.30)	(17.95)
	Hispanic	1 km	6.02	-9.10	-4.06	-11.53	17.97	11.74	3.93	-11.78	-2.49
			(8.50)	(8.59)	(8.28)	(12.25)	(11.93)	(12.04)	(8.49)	(8.58)	(8.76)

		1.5 km	1.64	-6.28	-2.82	-7.85	-2.37	16.88*	0.22	-11.48	-1.21
			(5.99)	(5.97)	(5.82)	(8.49)	(8.33)	(8.41)	(6.02)	(6.03)	(6.13)
	White	1 km	-4.47	-35.90*	-23.69	-4.42	10.34	27.31	3.22	-1.98	-13.78
			(18.72)	(18.11)	(18.34)	(26.59)	(27.71)	(26.23)	(19.31)	(18.73)	(19.37)
		1.5 km	3.46	-18.44	-9.04	-5.34	7.57	0.45	12.09	18.54	-5.43
			(13.12)	(12.67)	(12.57)	(18.19)	(18.68)	(18.58)	(13.25)	(13.14)	(13.09)
Unarmed	Black	1 km	53.80	-22.17	-106.33	-3.09	63.40	-58.00	67.45	113.53	22.09
White			(72.96)	(72.76)	(71.57)	(111.08)	(104.29)	(113.94)	(64.16)	(80.27)	(73.91)
		1.5 km	-1.75	-14.10	-7.17	-34.67	93.03	-50.12	-10.77	-19.55	47.70
			(49.26)	(50.44)	(45.56)	(72.58)	(70.09)	(73.39)	(45.84)	(50.88)	(48.40)
	Hispanic	1 km	0.52	-12.24	-4.83	30.56	17.54	25.86	17.85	-2.72	-9.27
			(16.04)	(16.11)	(15.40)	(22.35)	(21.77)	(21.74)	(15.65)	(15.44)	(15.73)
		1.5 km	-8.57	-6.61	-1.02	2.43	20.25	27.90	2.44	-5.66	1.40
			(11.11)	(11.23)	(10.86)	(15.91)	(15.50)	(15.63)	(11.03)	(10.88)	(11.04)
	White	1 km	-20.12	4.68	-11.67	-52.94*	-5.02	54.66*	-1.05	27.14	0.44
			(19.71)	(19.45)	(18.74)	(26.72)	(25.82)	(27.26)	(18.28)	(18.22)	(18.94)
		1.5 km	-8.53	-7.28	-5.37	-9.08	11.50	19.43	-8.53	-4.67	-1.56
			(13.56)	(13.37)	(13.01)	(18.83)	(18.29)	(19.06)	(12.52)	(12.63)	(12.85)
Armed	Black	1 km	38.66	-0.74	-15.07	107.78	-127.80*	-9.87	42.50	-1.64	24.01
White			(43.31)	(40.70)	(40.56)	(60.45)	(58.13)	(58.49)	(39.87)	(40.46)	(38.50)
		1.5 km	33.18	2.66	19.19	49.72	-47.37	-16.11	25.57	30.42	17.58
			(29.13)	(28.76)	(27.42)	(39.79)	(40.27)	(39.45)	(27.22)	(26.76)	(27.17)
	Hispanic	1 km	7.11	12.72	0.26	20.17	-4.07	8.42	-4.14	-11.49	2.50
			(9.76)	(9.52)	(9.47)	(13.53)	(13.41)	(13.20)	(9.17)	(9.25)	(9.40)
		1.5 km	-3.06	8.11	-7.67	1.55	2.42	3.50	-9.38	-6.32	5.06
			(6.64)	(6.54)	(6.48)	(9.23)	(9.20)	(9.02)	(6.31)	(6.27)	(6.35)
	White	1 km	-14.73	4.26	-13.84	-14.26	-9.37	-14.67	-8.31	-1.80	-16.39
			(12.24)	(11.96)	(11.79)	(16.78)	(16.80)	(16.55)	(11.50)	(11.09)	(11.19)

		1.5 km	-6.49	-5.87	-15.95	-4.52	-6.99	5.13	-7.11	-8.19	-8.46
			(8.57)	(8.40)	(8.21)	(11.84)	(11.70)	(11.64)	(8.01)	(7.76)	(7.82)
Unarmed Hispanic	Black	1 km	19.35	-1.25	-61.95	-20.01	-5.81	-61.95	-21.28	-30.23	-0.39
			(42.43)	(42.39)	(43.19)	(61.40)	(64.56)	(65.60)	(42.77)	(42.57)	(43.58)
		1.5 km	36.97	8.28	-61.97*	15.72	27.44	-70.47	-3.71	-29.73	-29.72
			(30.97)	(30.03)	(30.81)	(43.18)	(44.34)	(46.86)	(29.59)	(30.22)	(30.28)
	Hispanic	1 km	-9.98	-4.72	-0.76	-8.38	-9.90	4.10	10.80	2.46	-1.09
			(8.64)	(8.46)	(8.33)	(12.04)	(11.96)	(11.69)	(8.13)	(8.04)	(8.08)
		1.5 km	2.58	-12.72*	2.43	-0.51	-9.67	2.54	-0.62	-6.40	-4.32
			(6.02)	(5.87)	(5.82)	(8.36)	(8.26)	(8.14)	(5.60)	(5.53)	(5.59)
	White	1 km	-64.77**	-1.78	-54.29*	-34.50	-53.39	20.06	-51.09*	-4.38	-10.31
			(21.38)	(21.80)	(22.82)	(33.59)	(29.58)	(32.88)	(21.12)	(21.51)	(20.31)
		1.5 km	-25.17	1.64	-5.91	-24.95	-41.26*	37.60	-29.32*	0.71	-11.20
			(14.93)	(15.01)	(15.28)	(22.05)	(20.67)	(22.17)	(14.64)	(14.70)	(14.52)
Armed Hispanic	Black	1 km	-8.25	55.37	4.49	-5.66	36.23	5.58	21.12	25.80	15.99
			(29.02)	(29.32)	(28.70)	(40.34)	(41.28)	(40.42)	(28.87)	(27.41)	(27.66)
		1.5 km	-3.95	34.61	23.92	12.98	12.72	4.15	-17.69	35.56	29.62
			(20.08)	(20.26)	(20.27)	(28.99)	(29.28)	(28.22)	(20.20)	(19.45)	(19.55)
	Hispanic	1 km	15.72**	9.87*	0.53	-0.02	-6.99	-6.65	5.57	4.42	-3.47
			(5.15)	(5.01)	(5.01)	(7.09)	(6.99)	(7.03)	(4.84)	(4.71)	(4.76)
		1.5 km	6.78	1.97	0.28	-3.08	-2.87	-5.29	4.13	4.63	1.03
			(3.70)	(3.62)	(3.60)	(5.06)	(4.97)	(4.97)	(3.48)	(3.42)	(3.41)
	White	1 km	1.57	-9.32	-20.35	5.36	14.63	1.04	-0.89	8.57	-15.92
			(14.69)	(14.64)	(14.55)	(20.73)	(19.74)	(19.89)	(13.83)	(13.49)	(13.44)
		1.5 km	17.15	-1.44	-8.01	-6.06	7.41	7.94	-4.00	5.29	-12.18
			(10.05)	(10.16)	(9.89)	(14.07)	(13.67)	(13.69)	(9.41)	(9.23)	(9.12)

Table S4. Estimates for distances below 1km. Effect of exposure to police killing of unarmed Blacks on birth weight of Black infants by distance to event. Control variables include a linear county-specific trend, child's gender, proximity to any police killing and fixed effect terms for census tract, year-month and mother's id for the sibling model. The number of cases is 246,018 for the Difference-in-Difference model and 196,211 for the sibling model. *P < 0.05, **P < 0.01, ***P < 0.001

		Exposed before pregnancy			Exposed during pregnancy			Exposed after birth		
Model	Distance	13-18 months	7-12 months	1-6 months	1st trimester	2nd trimester	3rd trimester	1-6 months	7-12 months	13-18 months
DD Model	0.25 km	10.30	-26.18	-19.46	-82.20	-23.97	71.08	45.50	-6.48	22.15
		(44.20)	(42.42)	(46.28)	(69.40)	(63.55)	(63.91)	(43.38)	(46.39)	(51.34)
	0.5 km	26.21	9.49	-5.39	-72.94*	-36.43	-6.38	8.10	2.50	4.28
		(23.39)	(22.88)	(24.12)	(33.60)	(33.78)	(34.49)	(23.69)	(24.87)	(26.16)
	1 km	3.29	-0.18	-0.78	-44.14*	-53.43**	-8.58	14.01	24.45	-2.50
		(12.98)	(12.90)	(13.03)	(18.46)	(18.53)	(18.92)	(13.20)	(13.92)	(14.83)
Sib. Model	0.25 km	46.09	81.47	229.41*	40.72	-9.27	17.17	-5.35	21.08	44.20
		(78.00)	(87.95)	(109.10)	(126.87)	(117.51)	(132.41)	(91.40)	(100.98)	(102.23)
	0.5 km	-40.00	44.58	77.02	-104.58	-72.62	4.25	49.99	99.02	45.91
		(45.26)	(49.08)	(51.86)	(72.82)	(68.35)	(73.75)	(49.88)	(51.64)	(55.40)
	1 km	-22.04	8.48	24.32	-81.86*	-52.35	-28.11	23.48	49.83	-9.97
		(26.24)	(26.56)	(27.31)	(37.10)	(37.20)	(39.58)	(27.28)	(28.43)	(31.21)

Table S5. Sensitivity analysis for various definitions of trimester showing the effect of maternal exposure to police killings of unarmed Blacks during pregnancy on the birth weight of Black infants. The models include fixed definitions of trimester as consecutive 12 (reported analysis) or 11 weeks periods prior to the date of birth and an instrumental variable model for trimesters based on the last menstrual period (LMP). The instrumental variable model uses LMP-based trimesters for the three treatment indicators and exposure based on consecutive 12 weeks intervals as the instrumental variables. Control variables are listed in note to Figure 1. The number of cases is246,018 for the Difference-in-Difference (DD) model and 196,211 for the DD model with sibling fixed effects (Sib. Model). *P < 0.05, **P < 0.01, ***P < 0.001

			Exposed before pregnancy			Exposed during pregnancy			Exposed after birth		
Model	Trimester Definition	Distance	18-13 months	12-7 months	6-1 months	1st trimester	2nd trimester	3rd trimester	1-6 months	7-12 months	13-18 months
DD	12 weeks	1 km	3.29	-0.18	-0.78	-44.14*	-53.43**	-8.58	14.01	24.45	-2.50
	(reported)		(12.98)	(12.90)	(13.03)	(18.46)	(18.53)	(18.92)	(13.20)	(13.92)	(14.83)
		2 km	3.34	0.30	10.85	-26.43*	-23.97*	0.30	0.08	6.63	4.94
			(7.46)	(7.48)	(7.41)	(10.56)	(10.40)	(10.42)	(7.59)	(7.91)	(8.27)
	11 weeks	1 km	-4.84	-3.30	-5.85	-31.68	-54.98**	-10.78	13.58	24.24	-3.14
			(12.95)	(12.94)	(12.99)	(19.47)	(19.30)	(19.71)	(13.20)	(13.92)	(14.83)
		2 km	-0.53	-4.46	10.21	-35.58**	-18.96	1.21	-0.38	6.21	4.63
			(7.47)	(7.46)	(7.44)	(10.98)	(10.81)	(10.83)	(7.59)	(7.91)	(8.27)
2SLS DD	LMP-	1 km	3.50	-0.77	4.31	-44.62*	-58.42**	-6.21	14.02	24.95	-2.55
	based		(14.22)	(14.26)	(15.09)	(22.54)	(21.34)	(20.12)	(13.37)	(14.20)	(15.30)
		2 km	3.60	-1.13	15.45	-28.34*	-26.35*	1.78	0.21	6.62	5.01
			(8.18)	(8.33)	(8.54)	(12.81)	(11.92)	(11.12)	(7.69)	(8.10)	(8.55)
Sib. Model	12 weeks	1 km	-22.04	8.48	24.32	-81.86*	-52.35	-28.11	23.48	49.83	-9.97
	(reported)		(26.24)	(26.56)	(27.31)	(37.10)	(37.20)	(39.58)	(27.28)	(28.43)	(31.21)
		2 km	-6.00	2.76	19.13	-54.37*	-37.68	-8.58	21.44	28.04	11.06
			(15.34)	(15.15)	(15.41)	(21.60)	(21.72)	(21.84)	(15.66)	(16.62)	(16.89)

	11 weeks	1 km	-30.47	7.10	18.37	-83.33*	-46.98	-39.35	21.57	48.90	-11.86
			(26.30)	(26.59)	(27.39)	(37.97)	(39.46)	(41.00)	(27.26)	(28.41)	(31.22)
		2 km	-3.29	0.27	19.18	-60.09**	-38.98	-13.37	21.10	27.98	11.00
			(15.40)	(15.09)	(15.65)	(22.24)	(22.63)	(22.58)	(15.65)	(16.61)	(16.90)
2SLS	LMP-	1 km	-24.59	6.17	38.10	-94.33*	-54.35	-26.20	22.89	49.58	-10.81
Sib.Model	based		(28.93)	(29.62)	(31.54)	(47.25)	(42.25)	(42.13)	(27.79)	(28.98)	(32.16)
		2 km	-7.08	0.79	28.42	-61.30*	-40.11	-6.83	22.06	27.87	10.92
			(16.78)	(16.98)	(17.85)	(26.76)	(24.53)	(23.04)	(15.92)	(17.12)	(17.50)

Table S6. Sensitivity analysis for the effect of maternal exposure to police killings of unarmed Blacks during pregnancy on the birth weight of Black infants. The analysis uses 3 instead of 6 months periods for the time periods before and after police killings. Control variables are listed in note to Figure 1. The number of cases is 246,018 for the Difference-in-Difference (DD) model and 196,211 for the DD model with sibling fixed effects (Sib. Model). *P < 0.05, **P < 0.01, ***P < 0.001

		Exposed before pregnancy			Exposed during pregnancy			Exposed after birth		
Model	Distance	9-7 months	6-4 months	3-1 months	1st trimester	2nd trimester	3rd trimester	1-3 months	4-6 months	7-9 months
DD	1 km	2.57	-17.94	14.30	-44.81*	-53.94**	-9.36	8.08	22.09	32.30
		(17.70)	(17.66)	(18.25)	(18.43)	(18.50)	(18.89)	(18.10)	(18.29)	(19.38)
	2 km	0.79	-0.30	19.27	-26.79*	-24.17*	-0.50	3.74	-1.05	9.86
		(10.09)	(9.99)	(10.02)	(10.54)	(10.37)	(10.39)	(10.24)	(10.30)	(10.74)
Sib. Model	1 km	22.08	-5.58	56.21	-80.41*	-48.56	-26.96	24.13	32.79	117.34**
		(34.91)	(37.80)	(37.15)	(36.98)	(36.98)	(39.38)	(38.34)	(36.94)	(39.89)
	2 km	2.82	13.50	16.98	-55.54**	-39.84	-10.25	13.88	27.09	26.58
		(20.23)	(20.66)	(20.98)	(21.50)	(21.58)	(21.68)	(21.51)	(21.02)	(22.83)

Table S7. Effect of exposure to police killing of unarmed Blacks during pregnancy on residential mobility between first and second child for Black mothers. The sample is restricted to siblings and the level of analysis is a sibling pair. The outcome is defined as change in census tract between the first and second child. The treatment indicator is defined as exposure to police killing of unarmed Blacks during pregnancy for the second child based on address from the first birth. *P < 0.05, **P < 0.01, ***P < 0.001

	Within 1km		Within 2km		Within 3km	
	Without Controls	With Controls	Without Controls	With Controls	Without Controls	With Controls
Exposed to Pol. Kill.	-0.005	-0.004	0.002	-0.007	0.010	0.031
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Sib. Age diff. (years)	0.060***	0.063***	0.060***	0.063***	0.060***	0.063***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Maternal variables		✓		✓		✓
Census Tract FE		✓		✓		✓
Year-Month FE		✓		✓		✓
Observations	24,801	24,801	24,801	24,801	24,801	24,801

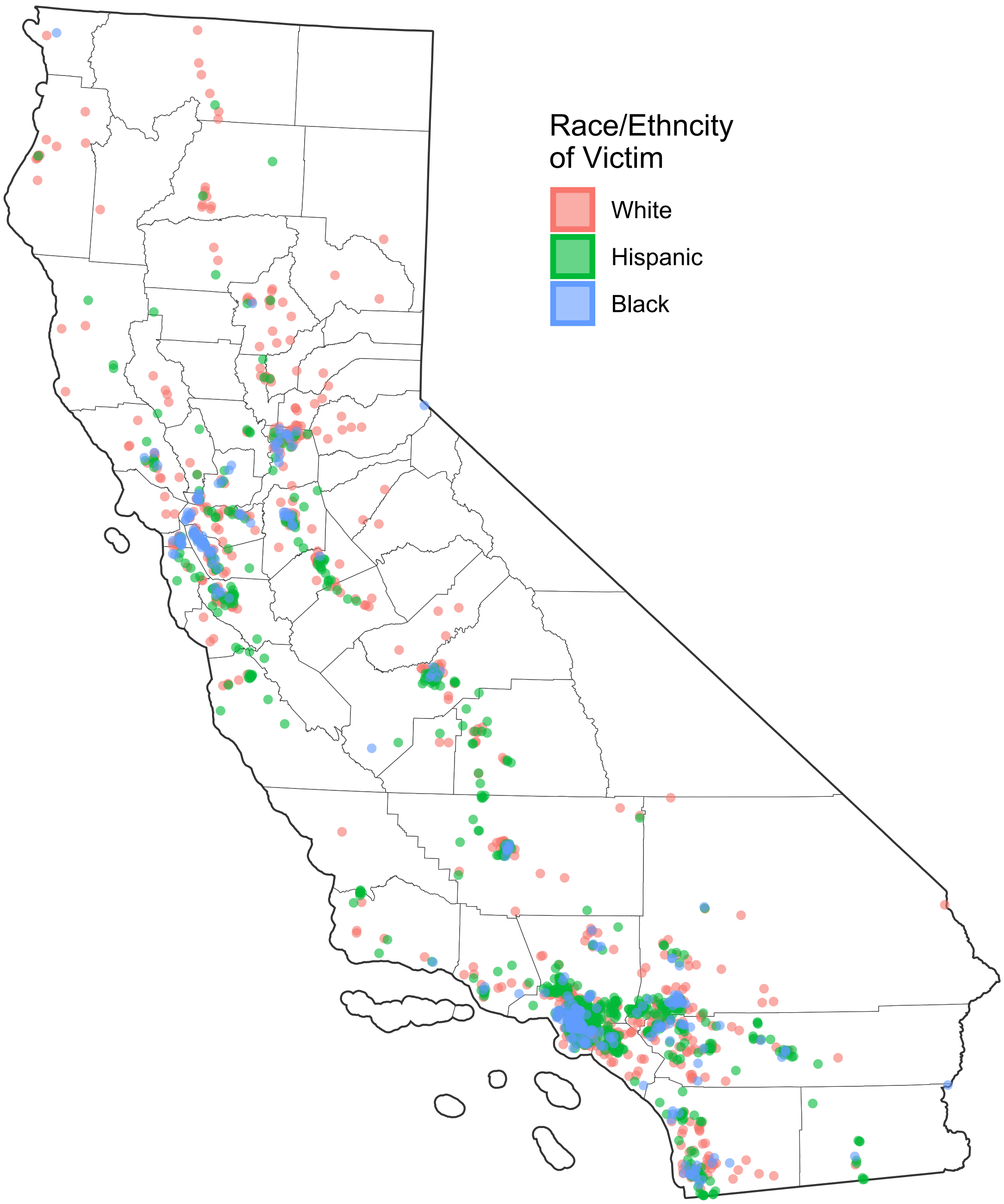
Table S8. 2SLS models for effect of exposure to police killing of unarmed Blacks during pregnancy within 1 km on birth weight of Black infants. The model specification is based on the sibling analysis in the main text but instruments the treatment indicators with exposure to police killings based on the residential address from the birth record of the first-born child. Results from the first stage regression show that the instruments are highly correlated with the treatment indicator with partial F-statistics well above 10,000 ($p < 0.000$). Control are listed in Figure 1. *P < 0.05, **P < 0.01, ***P < 0.001

	Birth Weight		Gestational Age	
	Sib. Model	2SLS Sib. Model	Sib. Model	2SLS Sib. Model
Exposed before pregnancy				
12-18 months before	-22.036	-5.091	-0.029	-0.012
	(26.24)	(47.79)	(0.12)	(0.21)
6-12 months before	8.477	17.207	0.150	0.166
	(26.56)	(42.42)	(0.12)	(0.19)
1-6 months before	24.324	23.455	0.038	-0.086
	(27.31)	(37.97)	(0.12)	(0.17)
Exposure during pregnancy				
First Trimester	-81.856*	-138.411**	-0.347*	-0.561*
	(37.10)	(50.30)	(0.16)	(0.22)
Second Trimester	-52.347	-26.629	-0.248	-0.307
	(37.20)	(49.64)	(0.16)	(0.22)
Third Trimester	-28.114	-16.713	0.036	-0.030
	(39.58)	(53.88)	(0.17)	(0.24)
Exposed after pregnancy				
1-6 months after	23.484	-4.454	-0.012	-0.150
	(27.28)	(38.61)	(0.12)	(0.17)
6-12 months after	49.834	47.293	0.220	0.366*
	(28.43)	(41.86)	(0.12)	(0.18)
12-18 months after	-9.975	32.968	-0.094	0.133
	(31.21)	(51.58)	(0.14)	(0.23)
Control variables	✓	✓	✓	✓
Mother Fixed Effect	✓	✓	✓	✓
Census Tract Fixed Effect	✓	✓	✓	✓

Year-Month Fixed Effect	✓	✓	✓	✓
Observations	196,118	196,118	196,118	196,118

Figures S1 to S5

Figure S1. Police killings in California, 2005-2017.



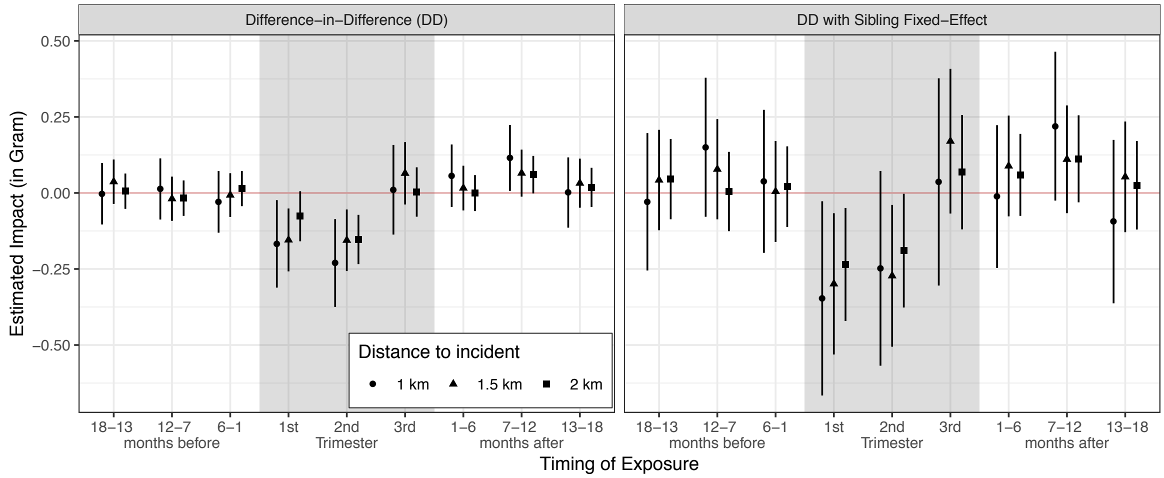


Figure S2. Effect of maternal exposure to police killings of unarmed Blacks before, during and after pregnancy on the gestational age of Black infants. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model (left) and a Difference-in-Difference model with sibling fixed-effects (right). See note for figure 1 about additional control variables. The number of cases is 246,018 for the Difference-in-Difference model and 196,211 for the sibling model.

Figure S3. Effect of maternal exposure to police killings within 1.5 km on gestational age in weeks by race/ethnicity of infant and characteristic of police killing. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model and a Difference-in-Difference model with mother fixed-effects. Confidence intervals for estimates with high uncertainty are cutoff to limit the scale of the y-axis.

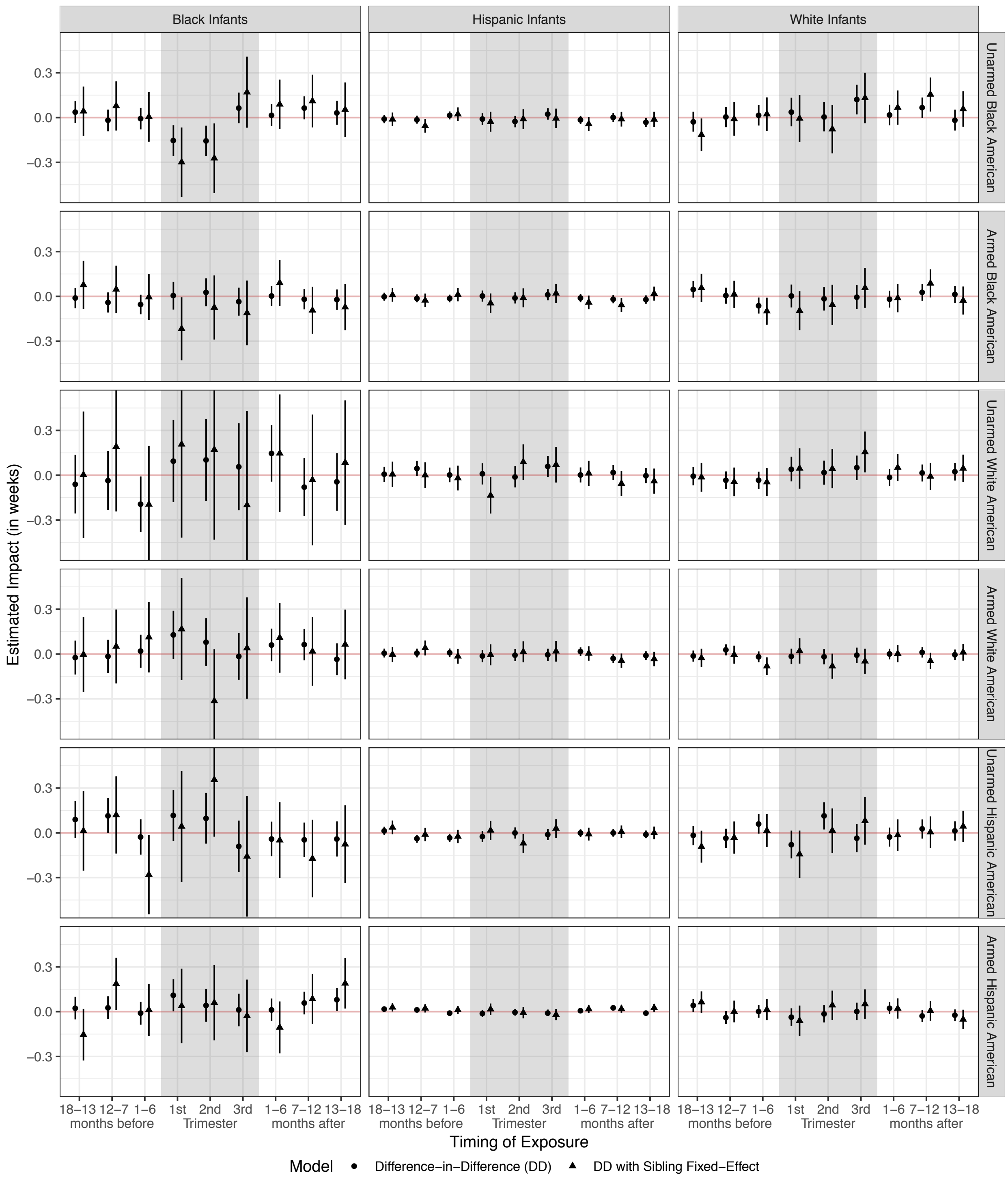


Figure S4. Effect of maternal exposure to police killings within 1.5 km on low birth weight in weeks by race/ethnicity of infant and characteristic of police killing. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model and a Difference-in-Difference model with mother fixed-effects. Confidence intervals for estimates with high uncertainty are cutoff to limit the scale of the y-axis.

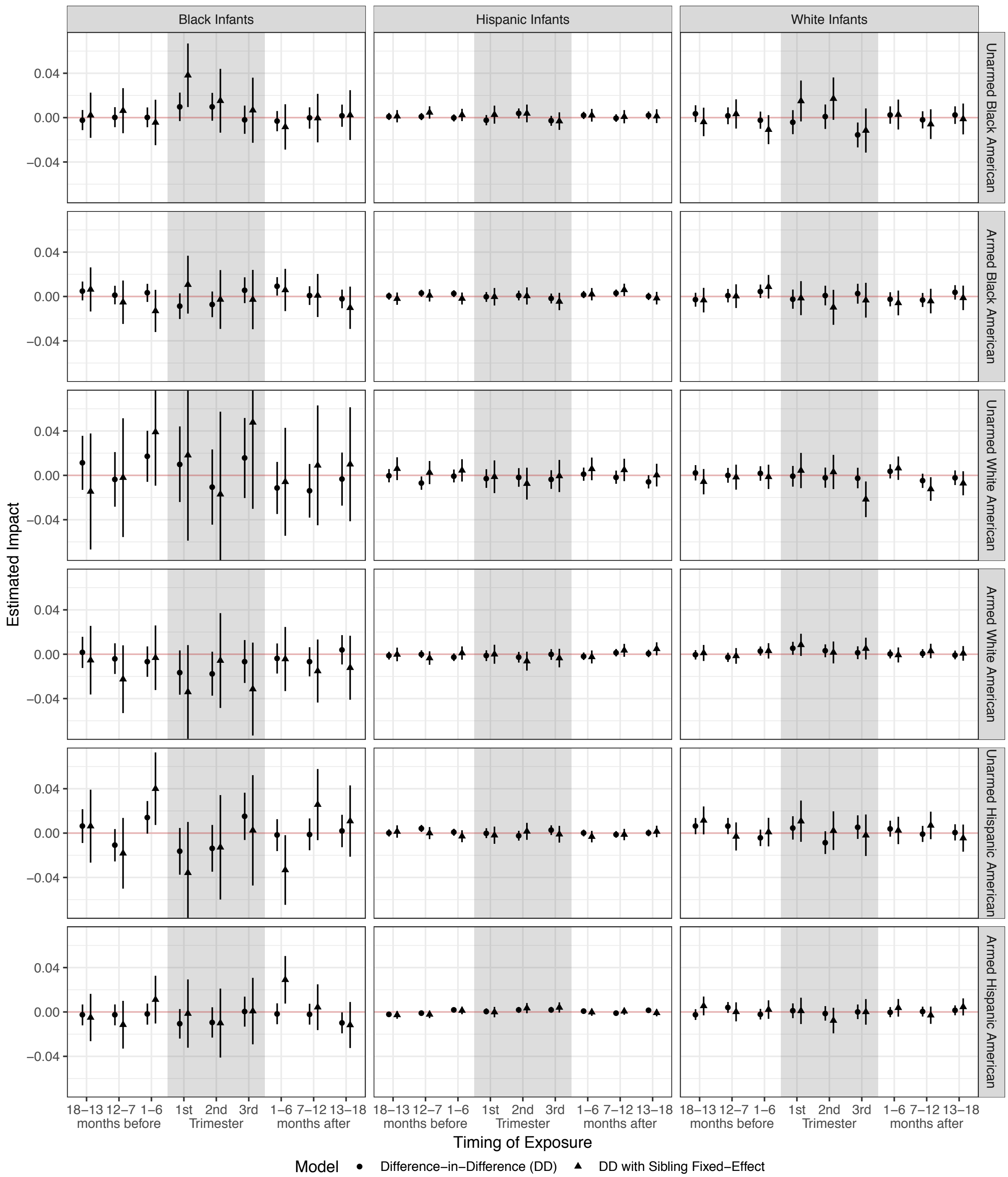
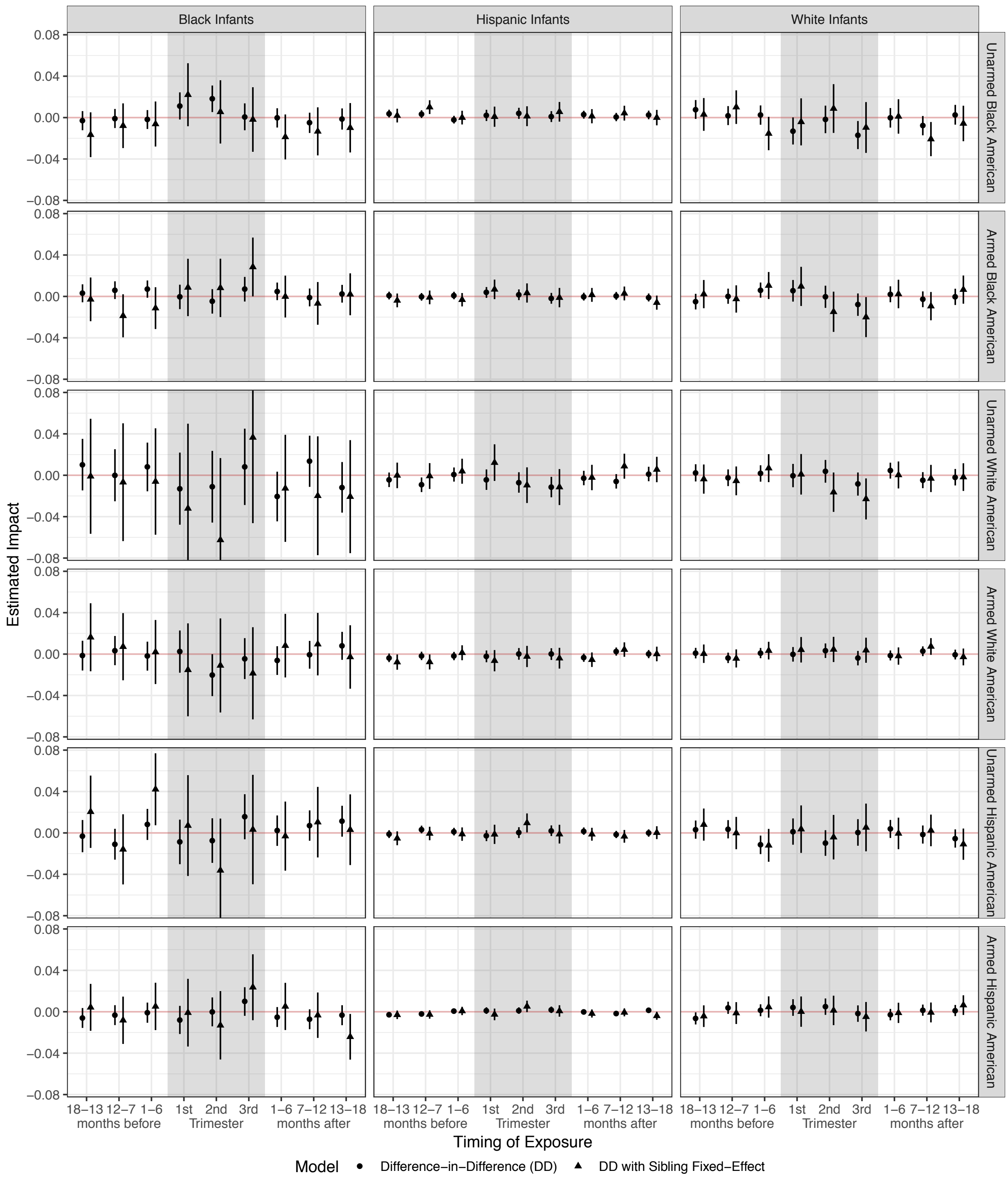


Figure S5. Effect of maternal exposure to police killings within 1.5 km on premature birth by race/ethnicity of infant and characteristic of police killing. Circles with lines represent point estimates with 95% confidence intervals from a Difference-in-Difference model and a Difference-in-Difference model with mother fixed-effects. Confidence intervals for estimates with high uncertainty are cutoff to limit the scale of the y-axis.



Preregistered Analysis Plan

This registration is a frozen, non-editable version of this project (/bthkg/)

This registration is currently embargoed. It will remain private until its embargo end date, Wednesday, Apr 01, 2020.

Register

Study Information

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Other

Study Information

Title

Provide the working title of your study. It is helpful if this is the same title that you submit for publication of your final manuscript, but it is not a requirement.

Police Violence and the Health of Black Infants

Authors

The author who submits the preregistration is the recipient of the award money and must also be an author of the published manuscript. Additional authors may be added or removed at any time.

[redacted]

Research Questions

Please list each research question included in this study.

What is the effect of maternal exposure to police killings of armed and unarmed Black Americans in the residential environment on the health of black infants in terms of birth weight and gestation age (preterm birth)? How does this effect compare to police killings involving white and Hispanic suspects and how does it differ by mother's race?

Hypotheses

For each of the research questions listed in the previous section, provide one or multiple specific and testable hypotheses. Please state if the hypotheses are directional or non-directional. If directional, state the direction. A predicted effect is also appropriate here.

I expect a negative effect of maternal in utero exposure to police killings of unarmed Black Americans in the residential environment on the health of black infants in terms of birth weight and gestation age.

I expect that the size this effect declines with spatial distance to the police killing.

I expect a smaller or no effect of maternal in utero exposure to police killings of armed Black Americans in the residential environment on the health of black infants in terms of birth weight and gestation age.

I expect a smaller or no effect of maternal in utero exposure to police killings of White and Hispanic Americans in the residential environment on the health of black infants in terms of birth weight and gestation age.

Sampling Plan

Existing Data

Preregistration is designed to make clear the distinction between confirmatory tests, specified prior to seeing the data, and exploratory analyses conducted after observing the data. Therefore, creating a research plan in which existing data will be used presents unique challenges. Please select the description that best describes your situation. Please do not hesitate to contact us if you have questions about how to answer this question (prereg@cos.io).

Registration prior to accessing the data

Explanation of existing data

If you indicate that you will be using some data that already exist in this study, please describe the steps you have taken to assure that you are unaware of any patterns or summary statistics in the data. This may include an explanation of how access to the data has been limited, who has observed the data, or how you have avoided observing any analysis of the specific data you will use in your study. The purpose of this question is to assure that the line between confirmatory and exploratory analysis is clear.

This study relies on two data sources. The first are birth certificates for all births in California from 2007 to 2017 assembled by the Center for Health Statistics and Informatics at the California Department of Public Health. These birth records include every birth in California (about half a million per year) with information on the date of birth, birth weight, the obstetric estimate of gestation age, and maternal and paternal characteristics such as full names, race, education and

residential address. For the geocoding of addresses on birth records, I will use the ArcGIS Desktop geocoder.
The project PI submitted a data application July 5, 2018. The application was approved on August 8, 2018 and the data is currently being prepared for delivery by Center for Health Statistics and Informatics at the California Department of Public Health. As of today, the PI and other project members had no access to data on California birth records.

The second data source is incident-level data on policing killings in California between 2005 and 2017. This data relies on Fatal Encounters (Burghart 2016) and our own extensive coding. The coding procedure is described below. The coding is currently in progress and will be finalized over the next weeks (see attached file for details on coding process). The result of this procedure is a comprehensive database on officer-involved killings in California between January 2005 and December 2017. The database includes information on the name of the victim, the date of the incident, the geographic location of the incident in terms of x and y coordinates, the race and age of the victim and whether the victim was armed or unarmed.

Data collection procedures

Please describe the process by which you will collect your data. If you are using human subjects, this should include the population from which you obtain subjects, recruitment efforts, payment for participation, how subjects will be selected for eligibility from the initial pool (e.g. inclusion and exclusion rules), and your study timeline. For studies that don't include human subjects, include information about how you will collect samples, duration of data gathering efforts, source or location of samples, or batch numbers you will use.

This study relies on two data sources. The first are birth certificates for all births in California from 2007 to 2017. Access to this data is provided by the Center for Health Statistics and Informatics at the California Department of Public Health. The second is incident-level data on all policing killings in California between 2005 and 2017. To collect comprehensive information on police killings, I will rely on Fatal Encounters with my own extensive coding to fill in missing information, correct errors and add additional variables to the database. The goal of Fatal Encounters is to "create a comprehensive national data-base of people who are killed through interactions with police" from 2000 to today (Burghart 2016). It is the most comprehensive data collection project that tracks officer-involved killings over multiple years. The Fatal Encounters archive relies on paid researchers, public records requests and crowd-sourced data. As of September 2018, the archive considers the information complete from January 2005 to December 2017. I will use Fatal Encounters to create a comprehensive dataset on officer-involved killings in California based on four steps.

First, I downloaded FE data on April 8, 2018 and restricted the database to all 2,553 incidents in California between 2005 and 2017.

Second, I use paid researchers to code the type of incident and restrict the cases to "intentional or purposeful police killing" and "unintentional police killing but result of extremely reckless, reckless or negligent use of force". Specifically, I follow [redacted] to define officer-involved killings or deaths as “any interaction with the police where the officer uses force and the person dies during or immediately after the interaction. This includes cases that result in death as a consequence of being shot, beaten, restrained, pepper sprayed, tasered, or otherwise harmed by police officers, whether on-duty or off-duty. … This includes acts where one or more police officers set in motion a chain of events that leads to the death of a suspect or another individual if the original act involved the use of police force. These cases might capture high speed chases or instances where a police officer kills a bystander when shooting at a suspect. The definition excludes (a) suicides, (b) accidents caused by suspects themselves (e.g. a fleeing suspect who causes a deadly car crash), and (c) police-caused accidents unrelated to the use of force (e.g. a car crash under normal traffic conditions that is not related to the vehicular pursuit of a suspect).” ([redacted]). At the time of writing this pre-registration, the coding process is not complete. Out of the first 1,143 cases, 743 cases were classified as “Intentional or purposeful”, 40 as “Unintentional but result of extremely reckless, reckless or negligent use of force” and the remaining 360 cases were excluded from the database. Excluded cases include duplicates, an incident in which an off-duty police officer shot and killed his wife during a domestic dispute, a case in which a suspect successfully fled to a forest area from the police and was found dead several days later from drowning in a nearby swamp, several cases in which the suspect kills bystanders during a car chase, and several cases in which the deaths are accidental or self-inflicted.

Third, I will verify and completed missing information for individual victims on the following variables: name, age, gender, race, date of the incident, geographic location, and names of the involved police agencies. As part of this verification process, I also added a variable “armed/unarmed” to the database. While the Fatal Encounters database is comprehensive and well-maintained, there are occasional errors and cases with missing information. Most important, information on victim race is missing for about 17.4% of all cases in California and considered unreliable for others. To address this problem, we use two independent coders from Amazon Mechanical Turk to verify and complete the information for all cases. We gave each coder the victim’s name, date of the incident, and the state in which it occurred. They were asked to collect information on the race of the victim, the involved police agencies, and the city in which the incident occurred from newspaper sources. A student research assistant cross-validated all cases for which the information from Fatal Encounters and our MTurk coders were not identical. This cross-validation and the comparison between the two independent coders strengthens the quality and accuracy of the data verification process.

Finally, I will use the Google Geocoding API to convert the address of the incident into geographic coordinates (latitude and longitude).

The result of this procedure is a comprehensive database of all officer-involved killings in California between January 2005 and December 2017. The database includes information on the name of the victim, the date of the incident, the geographic location of the incident in terms of x and y coordinates, the race and age of the victim and whether the victim was armed or unarmed.

no file selected

Sample size

Describe the sample size of your study. How many units will be analyzed in the study? This could be the number of people, birds, classrooms, plots, interactions, or countries included. If the units are not individuals, then describe the size requirements for each unit. If you are using a clustered or multilevel design, how many units are you collecting at each level of the analysis?

The approximate sample size is 5 million births in California and about 1,500 police killings.

Sample size rationale

This could include a power analysis or an arbitrary constraint such as time, money, or personnel.

N/A

Stopping rule

If your data collection procedures do not give you full control over your exact sample size, specify how you will decide when to terminate your data collection.

N/A

Variables

Manipulated variables

Describe all variables you plan to manipulate and the levels or treatment arms of each variable. For observational studies and meta-analyses, simply state that this is not applicable.

N/A

no file selected

Measured variables

Describe each variable that you will measure. This will include outcome measures, as well as any predictors or covariates that you will measure. You do not need to include any variables that you plan on collecting if they are not going to be included in the confirmatory analyses of this study.

OUTCOME VARIABLES
The analysis will focus on two outcome variables related to infant health: birth weight measured in grams and gestational age measured in weeks based on the obstetric estimate of gestation. These variables are common measures on infant health. Low birth weight and preterm birth are related to infant mortality (Callaghan et al. 2006; Centers for Disease Control and Prevention 2002; Kramer et al. 2000; McCormick 1985) and long-term outcomes such as cognitive development, test scores, ADHD and others (Bhutta et al. 2002). In alternative specifications, I will focus on high risk infants and examine binary indicators for low birth weight (<2,500 grams) and preterm delivery (<37 completed weeks of gestation).

TREATMENT INDICATOR/MAIN INDEPENDENT VARIABLE
To estimate the effect of maternal exposure to police killings, I will construct two terms separately for police killings of armed and unarmed Black Americans. The first is an indicator variable Near that measures proximity of mother's residence at time of birth to any police killing of an armed/unarmed Black American between 2005 and 2017 independent of the timing of the birth and incident. It is coded as 1 if any police killing occurred within a specific distance k and 0 otherwise regardless of when the incident occurred. There is no a priori or theoretical way to derive the correct value of the distance parameter k. Instead, the spatial scale of a potential effect is an empirical question. Hence, I will estimate models with different values of k ranging from 0.25 to 5 or even more kilometers. I will report multiple specifications to show at which distance a potential effect fades and disappears. Distances will be calculated using great circle distance based on the `st_distance` function in the R package `sf` (which uses the `geod_inverse` function from `proj.4` when the ` proj.4` version is larger than 4.8.0). The Near indicator measures whether at least one police killing occurred within the relevant distance.

The second is a set of 9 indicator variables that measures the timing of maternal exposure to police killings of armed/unarmed Black Americans within a specific distance k. The 9 indicators distinguish between incidents that happened in different time period before birth (similar to lead terms), exposure while in utero by trimester of gestation (the key treatment indicators) and different time periods after conception (similar to lagged terms). All 9 indicator variables are binary and coded as 1 if at least one police killing occurred during the specific time interval and within k kilometers of mother's residence and 0 otherwise. The three lead indicators are born 18 to 12, 12 to 6 and 6 to 1 months before the incident. They are designated as D_j where j ranges from -3 to -1. The effect of the three indicators should be zero because birth occurs before the incident. The terms help us to evaluate the plausibility of the design. The three treatment indicators measure exposure while in utero by trimester of gestation within k kilometers of mother's residence. They are defined as exposure during the 1st trimester D_0, 2nd trimester D_1 and 3rd trimester D_2 of gestation. The three terms are the key treatment indicator and estimate the effect of maternal exposure to police killings by trimester of gestation. Finally, the three lagged terms are defined as conceived 1 to 6, 6 to 12 or 12 to 18 months after a police killing within k kilometers of the incident. While birth outcomes might be affected by exposure to police killings prior to pregnancy, infants are not exposed in utero. Previous research and the most plausible mechanism linking maternal stress to birth outcomes suggest that the effect of the lagged terms should be small. Note that multiple of the 9 indicator variables for the timing of exposure can be coded as 1 if multiple police killings occurred within k kilometer. This specification makes it possible to examine changes in birth outcomes of black infants before and after police killings of armed/unarmed Black Americans.

CONTROL VARIABLES
Sex of child coded as 0 for male and 1 for female, mother's age (categorized as less than 20, 20–29, 30–34, or 35 years or older), mother's education (categorized as less than high school, high school, some college, college, advanced degree, or missing), and child parity (first, second, third, fourth born or higher, parity missing).

SIBLINGS
To identify full siblings in the sample, I will follow the procedure used by Liu, King, and Bearman (2010) based on California birth records from 1997 to 2007. In particular, I will exact match mother's date of birth, father's date of birth, and the first letter of the mother's maiden name for all children born between 2000 and 2017.

no file selected

Indices

If any measurements are going to be combined into an index (or even a mean), what measures will you use and how will they be combined? Include either a formula or a precise description of your method. If your are using a more complicated statistical method to combine measures (e.g. a factor analysis), you can note that here but describe the exact method in the analysis plan section.

N/A

no file selected

Design Plan

Study type

Please check one of the following statements

Observational Study - Data is collected from study subjects that are not randomly assigned to a treatment. This includes surveys, “natural experiments,” and regression discontinuity designs.

Blinding

Blinding describes who is aware of the experimental manipulations within a study. Mark all that apply.

No blinding is involved in this study.

Study design

Describe your study design. Examples include two-group, factorial, randomized block, and repeated measures. Is it a between (unpaired), within-subject (paired), or mixed design? Describe any counterbalancing required. Typical study designs for observation studies include cohort, cross sectional, and case-control studies.

Difference-in-Difference (DD) approach with and without sibling comparison

no file selected

Randomization

If you are doing a randomized study, how will you randomize, and at what level?

N/A

Analysis Plan

Statistical models

What statistical model will you use to test each hypothesis? Please include the type of model (e.g. ANOVA, multiple regression, SEM, etc) and the specification of the model (this includes each variable that will be included as predictors, outcomes, or covariates). Please specify any interactions that will be tested and remember that any test not included here must be noted as an exploratory test in your final article.

Note: The attachment includes a formatted version of the model description.

The goal of the analysis is to estimate the effect of maternal exposure to police killings of armed and unarmed Black Americans on birth outcomes for Black infants. Estimating the effect of police killings is challenging because police killings are not random. They are linked to crime and other neighborhood characteristics, which might also affect birth outcomes. To overcome this challenge, I rely on a Difference-in-Difference (DD) approach with and without sibling comparison (Angrist and Pischke 2008; Meyer 1995). The estimation strategy and model specification is motivated by previous research on the effect of Hydraulic fracturing on infant health (Currie, Greenstone, and Meckel 2017), and the effect of police killings (Ang 2018) and police surges ([redacted]) on student test scores.

All models will be estimated using a generalization of the within (fixed-effect) estimator for multiple high dimensional categorical variables using the lfe package in R (Gaure 2013). In particular, I will use the within transformation for the neighborhood and year-by-month fixed-effect term and for the mother fixed effect term in the model with sibling comparison.

DIFFERENCE-IN-DIFFERENCE MODEL
The difference-in-difference approach leverages millions of birth records from California to compare changes in birth outcomes for Black infants in exposed areas born in different time periods before and after police killings of Black Americans to changes in birth outcomes for control cases in unaffected areas. In particular, I distinguish nine time period for children who are born 18-12, 12-6 and 6-1 months before a police killing, those who are exposed during the first, second and third trimester in utero, and those who are conceived in the 1-6, 6-12 and 12-18 months after an incident. Formally, I plan to estimate the following regression model with clustered standard errors on the neighborhood level to address potential serial correlation problems (Bertrand, Duflo, and Mullainathan 2004):

$y\_icjt=π\_cj+η\_t+γ\_c year+β\_1 Near\_i+∑\_(r=-3)^5 (δ\_r Exposure\_(i,r)) + β\_2 X\_icjt + ε\_icjt$

where the dependent variables are birth outcomes for mother i in county c in census tract j and at year-by-month time period t (e.g. January 2014). The model includes a stable neighborhood effect π_cj that controls for mean differences in birth outcomes across census tracts, and a year-by-month time effect η_t that captures differences in birth outcomes over years and months (e.g. January 2014) that are constant across all births such as seasonal fluctuations or general time trends. In addition, the model includes county-specific, linear time trends γ_c year that captures different temporal trends in birth outcomes across California's 58 counties. The vector X_ijt consists of maternal and child characteristics. It includes sex of child coded as 0 for male and 1 for female, mother's age (categorized as less than 20, 20–29, 30–34, or 35 years or older), mother's education (categorized as less than high school, high school, some college, college, advanced degree, or missing), and child parity (first, second, third, fourth born or higher, parity missing).

To estimate the effect of maternal exposure to police killings, the model includes two terms that will be constructed separately for police killings of armed and unarmed Black Americans. The first is an indicator variable Near_i that measures proximity of mother's residence at time of birth to any police killing of an armed/unarmed Black American between 2005 and 2017 independent of the timing of the birth and incident. It is coded as 1 if any police killing occurred within a specific distance k and 0 otherwise regardless of when the incident occurred. There is no a priori or theoretical way to derive the correct value of the distance parameter k. Instead, the spatial scale of a potential effect is an empirical question. Hence, I will estimate models with different values of k ranging from 0.25 to 5 or even more kilometers. I will report multiple specifications to show at which distance a potential effect fades and disappears. Distances will be calculated using great circle distance based on the `st_distance` function in the R package `sf` (which uses the `geod_inverse` function from `proj.4` when the ` proj.4` version is larger than 4.8.0). The Near_i indicator measures whether at least one police killing occurred within the relevant distance.

The second is a set of 9 indicator variables that measures the timing of maternal exposure to police killings of armed/unarmed Black Americans within a specific distance k (see Table 1 for a description of the 9 terms). The 9 indicators distinguish between incidents that happened in different time period before birth (similar to lead terms), exposure while in utero by trimester of gestation (the key treatment indicators) and different time periods after conception (similar to lagged terms). All 9 indicator variables are binary and coded as 1 if at least one police killing occurred during the specific time interval and within k kilometers of mother's residence and 0 otherwise. The three lead indicators are born 18 to 12, 12 to 6 and 6 to 1 months before the incident. They are designated as D_j where j ranges from -3 to -1. The effect of the three indicators should be zero because birth occurs before the incident. The terms help us to evaluate the plausibility of the design. The three treatment indicators measure exposure while in utero by trimester of gestation within k kilometers of mother's residence. They are defined as exposure during the 1st trimester D_0, 2nd trimester D_1 and 3rd trimester D_2 of gestation. The three terms are the key treatment indicator and estimate the effect of maternal exposure to police killings by trimester of gestation. Finally, the three lagged terms are defined as conceived 1 to 6, 6 to 12 or 12 to 18 months after a police killing within k kilometers of the incident. While birth outcomes might be affected by exposure to police killings prior to pregnancy, infants are not exposed in utero. Previous research and the most plausible mechanism linking maternal stress to birth outcomes suggest that the effect of the lagged terms should be small. Note that multiple of the 9 indicator variables for the timing of exposure can be coded as 1 if multiple police killings occurred within k kilometer. This specification makes it possible to examine changes in birth outcomes of black infants before and after police killings of armed/unarmed Black Americans.

I will compare the estimates for maternal exposure to police killings of Black Americans with similar estimates for killings of white and Hispanic victims on the health of Black, white and Hispanic infants. For this purpose, I will construct separate exposure indicators for police killings involving Black, white and Hispanic victims and estimate the models separately for the sample of black, white and Hispanic infants.

TABLE 1: Indicator variables for maternal exposure to police killing

Term	Description
D_(-3)	Born 12-18 months before incident within k km
D_(-2)	Born 6-12 months before incident within k km
D_(-1)	Born 1-6 months before incident within k km
D_0	Exposure within k km during 1st trimester of gestation
D_1	Exposure within k km during 2nd trimester of gestation
D_2	Exposure within k km during 3rd trimester of gestation
D_3	Conceived/LMP 1-6 months after incident within k km
D_4	Conceived/LMP 6-12 months after incident within k km
D_5	Conceived/LMP 12-18 months after incident within k km

SIBLING COMPARISON

My second model will use a sibling comparison based on the following specification

$$y_{icjt}=\alpha_i+\pi_{cj}+\eta_t+\gamma_c\, year+\beta_1\, Near_i+\sum_{r=-3}^{5} (\delta_r\, Exposure_{i,r}) + \beta_2\, X_{icjt}+\varepsilon_{icjt}$$

The individual-level fixed effect term α_i accounts for all observed and unobserved characteristics of the mother that are constant over time. As a consequence, the vector of covariates now only includes child's sex and excludes all characteristics that are constant or almost constant over time.

PLAUSIBILITY OF ESTIMATION STRATEGY AND CRIME AS AN ALTERNATIVE EXPLANATION

The core assumption of the DD approach is that in the absence of police killings changes in birth outcomes of exposed children would have been the same as changes in birth outcomes of children in control areas (common trend assumption). The estimates of δ_r for the lag (r< 0) and to some extend lead (r> 2) terms make it possible to evaluate the common trend assumption indirectly.

However, time-specific, neighborhood-level factors that are related to police killings and birth outcomes still threaten the identification strategy. Most importantly, unobserved trends in crime rates or policing may account for both police shootings and changes in birth outcomes. From this perspective, a potential effect on birth outcomes is not caused by exposure to officer-involved killings but instead by changes in crime rates that increase police activity and officer-involved killings. While the model accounts for county-specific linear trends in birth outcomes and the specification of the exposure variable focuses on the nine months of pregnancy, local crime waves (as opposed to general trends) that coincide with police killings are a potential threat to my identification strategy particularly because previous research links crime with birth outcomes (Torche and Villarreal 2014). However, previous research also shows that police killings are unrelated to homicides, violent crimes and arrests after accounting for neighborhood and time fixed effects similar to the ones used in my model. In particular, Ang (2018) uses data from Los Angeles to examine the relation between police killings and homicides, violent crimes and arrests. He finds no evidence for changes in crime or arrests prior to or following police killings. This finding supports the argument that police killings are exogenous after conditioning on neighborhood and time fixed effects.

In addition, the comparison between the effect of maternal exposure to police killings of armed and unarmed Black Americans provides further evidence. In particular, the alternative explanation of a potential effect based on crime as a confounder has opposite implications for the type of police killings that are particularly consequential. If police killings affect birth outcomes, the effect of incidents that are perceived as unjustified involving a suspect that pose little threat should be more pronounced. However, if crime is an unobserved confounder that biases the results, justified police killings related to serious crime should have a larger effect on birth outcomes. I will exploit these contradicting implications to rule out crime as an alternative explanation. In particular, I will compare the effect of maternal exposure for incidents involving armed and unarmed suspect as a measure of the threat posed by suspects.

pre-analysis-plan-v3-statistical-models.pdf (/project/x8by4/files/osfstorage/5bb3b72a6ca1d00016b9f7e1/)

Transformations

If you plan on transforming, centering, recoding the data, or will require a coding scheme for categorical variables, please describe that process.

The control variables include sex of child coded as 0 for male and 1 for female, mother's age (categorized as less than 20, 20–29, 30–34, or 35 years or older), mother's education (categorized as less than high school, high school, some college, college, advanced degree, or missing), and child parity (first, second, third, fourth born or higher, parity missing).

Follow-up analyses

If not specified previously, will you be conducting any confirmatory analyses to follow up on effects in your statistical model, such as subgroup analyses, pairwise or complex contrasts, or follow-up tests from interactions? Remember that any analyses not specified in this research plan must be noted as exploratory.

N/A

Inference criteria

What criteria will you use to make inferences? Please describe the information you'll use (e.g. specify the p-values, Bayes factors, specific model fit indices), as well as cut-off criterion, where appropriate. Will you be using one or two tailed tests for each of your analyses? If you are comparing multiple conditions or testing multiple hypotheses, will you account for this?

Thresholds of 0.05 and 0.01 for p-values will be reported but I will use effect sizes, standard errors and p-values to evaluate the results.

Data exclusion

How will you determine which data points or samples (if any) to exclude from your analyses? How will outliers be handled?

I will restrict the sample to Black mothers and singleton births considering that twins and other multiples have lower birth weight and worse health at birth. In later steps of the analysis, I will compare the results to white and Hispanic mothers.

Missing data

How will you deal with incomplete or missing data?

All analysis will exclude cases with missing information on birth date, birth weight, gestation age, mother's race or mother's residential address.

Exploratory analysis

If you plan to explore your data set to look for unexpected differences or relationships, you may describe those tests here. An exploratory test is any test where a prediction is not made up front, or there are multiple possible tests that you are going to use. A statistically significant finding in an exploratory test is a great way to form a new confirmatory hypothesis, which could be registered at a later time.

N/A

Scripts

Upload an analysis script with clear comments

This optional step is helpful in order to create a process that is completely transparent and increase the likelihood that your analysis can be replicated. We recommend that you run the code on a simulated dataset in order to check that it will run without errors.

no file selected

Other

Other

If there is any additional information that you feel needs to be included in your preregistration, please enter it here.

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Meyer, Bruce D. 1995. “Natural and Quasi-Experiments in Economics.” Journal of Business & Economic Statistics 13(2):151–61.

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Register

Summary

Summary

Provide a narrative summary of what is contained in this registration, or how it differs from prior registrations.

This document outlines four small revisions to the pre-analysis plan submitted on October 2, 2018, and available at https://osf.io/x8by4/register/565fb3678c5e4a66b5582f67. The revisions were written prior to obtaining access to geo-coded information on all births in California and therefore before the central treatment indicator – maternal exposure to police killings in the residential environment – could be constructed. The revisions are based on access to other information on birth records aside from geographic coordinates, which makes it possible to clarify some coding decisions. In particular, the PI received the data from the Center for Health Statistics and Informatics at the California Department of Public Health on October 10, 2018, and I expect to receive the geographic coordinates on October 22 or 23, 2018.

The pre-analysis plan outlines a strategy to estimate the effect of maternal exposure to police violence on infant health. This revision to the pre-analysis plan includes four changes:

1. The analysis will focus on birth records from 2007-2016 because the data delivery did not include data from 2017.

2. Sample restriction: California birth records include information on all births in California and out-of-state births to California residents. I will restrict the analysis to singleton, in-state births to California residents. This excludes births in California to mothers who life in a different state and out-of-state births to California residents. Note that the pre-analysis plan already restricted the sample to singleton births. As discussed in the pre-analysis plan, the analysis also excludes cases with missing information on birth date, birth weight, gestation age, mother's age, mother's race/ethnicity or mother's residential ad-dress (the only addition to this list is mother's age, which is

missing for 25 out of over 4 million births). With these restrictions, the sample size is 4,041,831 births (prior to excluding births with incorrect information on mother's residential address).

3. Recoding: Based on access to the documentation and part of the data, I want to clarify the coding for the following variables:

a. Mother's Race/Ethnicity: The three relevant racial/ethnic groups will be coded as non-Hispanic White, non-Hispanic Black and Hispanic. Mothers with multiple race categories are excluded from these three groups unless they are Hispanic.

b. Mother's education: The revised coding uses six categories for "less than high school", "high school degree", "some college or associate degree", "Bachelor's degree", "advanced degree" (master, doctorate, or professional degree), and "missing". The only change compared to the pre-analysis plan is the combination of the category "some college" and "associate degree".

4. Siblings: The approach to identify full siblings remains the same but I will exclude birth records with missing information on any of the variables used in the matching procedure (most importantly, father's birth date).