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Research Paper

Gestational exposure to fatal police violence and pregnancy loss in US core based statistical areas, 2013–2015

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ABSTRACT

Background: Fatal police violence in the United States disproportionately affects Black, Native American, and Hispanic people, and for these groups it is a racially oppressive population-level stressor that we hypothesize increases the risk of pregnancy loss. Focusing on core based statical areas (CBSAs) surrounding small and large urban centers, we accordingly tested whether gestational exposure to fatal police violence decreased the number of live births, which is reflective of a rise in lost pregnancies.

Methods: Our observational study linked microdata for all births (N = 7,709,300) in 520 CBSAs with at least one incident of fatal police violence in 2013–2015 to Fatal Encounters, a database that prospectively identified 2594 police-related fatalities using online media reports and public records. We estimated the association between month-to-month fatal police violence and conceptions resulting in live births using distributed lag quasi-Poisson models with CBSA-level fixed effects, adjusted for seasonality and stratified by maternal race/ethnicity.

Findings: For each additional police-related fatality that occurred in the first through sixth months of gestation, we observed a 0.14% decrease (95% confidence interval: 0.05%, 0.23%) in the total number of live births within CBSAs, and a 0.29% decrease in births to Black women (95% CI: 0.11%, 0.48%). The association was null for births to White women.

Interpretation: Our findings suggest fatal police violence may have population-level consequences for pregnancy loss and adds to the evidence regarding the importance of preventing these fatalities.

1. Introduction

Black, Hispanic, and Native American people are disproportionately stopped, surveilled, and killed by police [1,2]. The Movement for Black Lives and other activist efforts have brought national attention to fatal police violence as a devaluing of Black personhood and the large-scale harms brought about by structural racism [3], defined here as explicit and nonexplicit laws, policies, and institutional legacies that perpetuate racial hierarchy and have consequences for racial/ethnic health inequities [4]. Public health researchers and practitioners have increasingly recognized fatal police violence as a public health problem because of the physical and mental health consequences for those directly affected as well as their families and communities [5,6].

Given historical and contemporary patterns of racialized police surveillance and violence [7], Black, Hispanic, and Native American people may experience fatal police violence as threatening and distressing actions by the state [8]. Fatal police violence can therefore be understood as a population-level stressor [9] with potential psychosocial and physiologic implications [10]. Scholars have hypothesized that police violence may prompt groups that are routinely targeted by police actions to recall previous negative experiences with police [9], provoke heightened vigilance and disrupted sleep [10], increase antenatal depressive symptoms [11], and inequities in preterm birth [12–15]. Public discourse and interpersonal conflict over whether racism underlies police violence can themselves be stressors. Media coverage of fatal police violence in local news outlets, as well as video

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Research in context

Evidence before this study

In recent years, activists have brought needed attention to deaths involving police as a public health emergency. In addition to ongoing epidemiologic efforts to accurately monitor, map and describe the distribution of these fatalities in the U.S., research has also sought to identify contextual or "spillover" effects for additional health outcomes. As of March 12, 2021, a PubMed search of the terms "police" AND ("fatality" OR "violence" OR "killing" OR "use of force" OR "brutality" OR "legal intervention") AND ("birth" OR "pregnancy" OR "fetal loss") retrieved 99 results, of which less than a handful have described the relationship between violence by police and birth outcomes and none have examined pregnancy loss. Birth outcomes have been shown to be adversely impacted by contextual stressors during pregnancy, particularly when they occur earlier in gestation.

Added value of this study

This study provides national estimates of the association between U.S. fatal police violence and pregnancy loss, overall and across maternal race/ethnicity using comprehensive birth certificate microdata. We found that for each additional police-related fatality that occurred in the first through sixth months of gestation, there was a 0.14% decrease (95% CI: 0.05%, 0.23%) in the total number of live births within those areas, indicative of a rise in lost pregnancies. Among Black women, we found a 0.29% decrease in births (95% CI: 0.11%, 0.48%), but the association was null for births to White women.

Implications of all the available evidence

Fatal police violence is a determinant of population health and birth outcomes specifically. Public health researchers and practitioners have a role both in advocating for accurate data monitoring for these deaths and in continuing to document consequences for population health to inform preventative policy and advocacy efforts.

documentation and discussion on social media contribute to the spatial proliferation of this stressor [9].

To understand the potential implications of fatal police violence for the health of surrounding communities, we apply ecosocial theory, which urges attention to how structural racism may become biologically embodied and potentially contribute to racial/ethnic health inequities during sensitive periods in lifecourse development [16]. Stressful contextual exposures *in utero*, particularly in early pregnancy [17], have been shown to negatively affect birth outcomes, including pregnancy loss [18]. Moreover, previous research suggests stressful exposures may be more harmful to male births given greater hypothesized sensitivity to elevated maternal corticosteroids [19]. Yet, no published studies have examined potential adverse consequences of fatal police violence for pregnancy loss, overall or across race/ethnicity, which is necessary for a full accounting of the impact of lethal actions by police as they may extend beyond those who are directly physically harmed and contribute to racial/ethnic health inequities [6,15].

Our analysis brings together national data on police-related fatalities and birth certificate records to examine whether month-to-month increases in fatal police violence are associated with decreases in the number of live births in that area, which is reflective of a rise in lost pregnancies. We hypothesized that, (1) in addition to an overall association between fatal police violence and fewer births, the association will be stronger among male births and for exposures early in gestation (within the first trimester), and (2) there will be larger decreases in births to Black and Hispanic women as compared to decreases among births to White women.

2. Methods

2.1. Data and study population

We used individual-level birth certificate microdata for all live births in the U.S. from 2013 to 2015 from National Center for Health Statistics (NCHS), which provided data on month and year of birth and maternal race/ethnicity. If birth certificates were missing maternal race/ethnicity or month of birth, these were imputed by NCHS [20]. We used the following maternal racial/ethnic classifications from NCHS: non-Hispanic Black, non-Hispanic White, non-Hispanic American Indian or Alaska Native, non-Hispanic Asian or Pacific Islander (hereafter referred to as "Black", "White", "American Indian & Alaska Native" and "Asian" for brevity) and Hispanic [20]. To ensure accurate exposure classification over the gestational period, we restricted the analysis to births not missing gestational age (99.92% of births). Date of conception was estimated from month of birth and gestational age (in weeks), since exact day of birth was not provided; we accordingly calculated conception dates by subtracting gestational age from the fifteenth of the month for all births.

Data on police-related fatalities for 2013−2015 were from Fatal Encounters [21] an, open-access real-time database that identifies deaths that involve law enforcement officers systematically using media reports and public records (data downloaded May 1, 2019). We use "police" to describe all law enforcement officers at any jurisdictional level. Incidents were verified by paid researchers to ensure consistent information across multiple data sources [21]. Victim's race/ethnicity was provided for 90% of the deaths. The resulting dataset was more comprehensive than official vital statistics and other federal data sources, which have been shown to substantially underestimate the number of police-related fatalities during these years [22]. Fatal Encounters also provided latitudes and longitudes for each incident, which we geocoded using ArcGIS version 10.6.1 to assign each death a county.

We linked birth certificate data to Fatal Encounters using mother's county of residence; when this was not available (<1% of births), we used county of birth occurrence. Counties are nested within core-based statistical areas (CBSAs), which are Census-defined metropolitan and micropolitan areas that, respectively, either contain an urbanized areas with >50,000 people or have at least one urban center of >10,000 and <50,000 people [23]. Given that we observed 94% of incidents of fatal police violence occurred in or near urban areas, and that urban residents may live, work, and spend most of their time across county lines, the main results we present use CBSAs (n = 520, including 316 metropolitan and 204 micropolitan statistical areas). Moreover, although we had access to county-level data, increasing the unit of analysis from counties to CBSAs limited the number of months with zero police-related fatalities. Our analysis is therefore restricted to 7,902,956 births from CBSAs where at least one incident of fatal police violence occurred over the study period (56% of all CBSAs in the US), and we excluded births with estimated conception dates before the Fatal Encounters data were available (1/1/2013) and for which incomplete exposure data were available (births conceived after 3/1/2015).

Our primary analyses also excluded law-enforcement related fatalities classified as "accidental," consistent with the definition used by Edwards et al. [24], because these may have received less media attention and therefore have less of a contextual health impact. This removed deaths reported to be accidents (including drug overdoses [n = 27; 0.7%], other medical emergencies [n = 62;

1.7%], drowning [n = 15; 0.4%], falling from a height [n = 7, 0.2%], or vehicular collisions [n = 902; 25.0%]), leaving 2594 fatalities for study inclusion. The Harvard Office of Human Research Administration approved all study protocols and the NCHS approved use of birth microdata. Per the data use agreement with NCHS: (1) we do not report results from cell sizes with fewer than 10 observations, and (2) authors JJ and NK had access to restricted birth microdata, although code and results were shared with the rest of the study team.

2.2. Study design

By identifying month of conception as described above, we considered the number of conceptions in a given month that eventually resulted in live births, which we refer to as live birth identified conceptions. We then use this as the outcome in a distributed lag model to estimate associations between lagged month-to-month changes in fatal police violence and changes in live birth identified conceptions, similar to what has been previously described [25]. By implementing a monthly forward lag of the exposure starting at the estimated month of conception for each CBSA, the models are able to evaluate how a change in fatal police violence after conception might affect the number of pregnancies in a CBSA that result in a live birth, and therefore also its complement, those that do not result in a live birth. Put differently, the number of live births in a CBSA in a given month reflects the total number of conceptions that happened 9 months prior minus any pregnancies that were lost. Because we examine incidents of fatal police violence that occur after conception, we believe the observed changes in live births reflect lost pregnancies and not changes in conception patterns.

The advantage of this modeling framework is that, when used with CBSA fixed effects, it is robust to confounders that do not change on a month to month timescale. For example, maternal-level determinants of adverse birth outcomes such as access to prenatal care or smoking are unlikely to act as confounders because they cannot cause month to month changes in the CBSA's number of live births. Similarly, area-level demographic attributes (e.g., percentages of residents living in poverty) are unlikely to confound the association because (1) our fixed effects models estimate a within-CBSA association, and (2) within CBSAs, these are not time varying at the month level such that they co-occur with changes in fatal police violence independent of seasonality. Furthermore, although the number of live births can fluctuate with the number of conceptions, this would not introduce confounding because it is independent of fatalities that occur *after* conception [25]. However, we do adjust for seasonality using a sine-cosine pair for each calendar year to account for long-term seasonal trends in births and conceptions [26] that we observed overlapped with the temporal trend in police-related fatalities.

2.3. Statistical analysis

We estimated distributed lag Poisson models with a quasi-likelihood to account for overdispersion of the outcome given covariates using the dlnm package in *R* version 3.6.1 [27]. These models assume that there is a linear association between the month-to-month change in live births in a CBSA and the number of police-related fatalities and that this association is a smooth function over time. Visual inspections of the data suggested that these assumptions hold. The distributed lag models estimate the association between changes in the total number of live births and fatal police violence using natural splines, with degrees of freedom selected based on the quasi-Akaike Information Criterion. Our primary analyses present distributed lag models over the first two trimesters of pregnancy, motivated by prior literature identifying this window as a sensitive period [18].

Given that an incident of fatal police violence may have a different impact in areas where these events are more frequent compared with areas where they are rare, we stratified across CBSAs that experienced $\leq$ 3 fatalities over the three year study period (an average of one fatality per year; 75% of CBSAs experienced $\leq$ 3 fatalities) and those that lived in CBSAs with $\geq$ 4 fatalities. We additionally present models stratified by maternal race/ethnicity, given our conceptualization of fatal police violence as a racialized stressor. However, due to smaller numbers of births and therefore more imprecise estimates for American Indian & Alaska Native women relative to the other racial/ethnic categories, these results are not presented.

We also fit models among Black and White women with race-concordant exposures, in 149 CBSAs with $\geq$ 1 Black and $\geq$ 1 White fatalities over the study period. There were too few CBSAs for which fatalities of other racial/ethnic groups met these criteria to provide meaningfully precise estimates. We then evaluate the opposite in this subset of CBSAs: fatal police violence against White people with births to Black women and vice versa. Lastly, we examined models stratified by sex of the birth (male/female) to test hypotheses related to sex-specific vulnerability to stressful contextual exposures.

2.4. Sensitivity analyses

We conducted several sensitivity analyses to assess the robustness of our findings. First, we examined associations using a nine-month forward lag to determine whether results are consistent with our primary analyses that used a six-month forward lag. Our second sensitivity analysis repeated our main models using counties as the unit of analysis using n = 1060 counties with at least one police-related fatality. Our third sensitivity analysis did not exclude police-related fatalities classified as "accidental" to address potential error in the classification of cause of death.

Our fourth sensitivity analysis adjusted for crime because it has been shown to increase risk of adverse birth outcomes [28] and because incidents of crime are reported by law enforcement agencies and are therefore also indicative of greater police presence, which could increase the likelihood of a police-related fatality, independent of seasonality. To do so, we linked our dataset to one we constructed from agency-level reports of crimes from the Federal Bureau of Investigation's Uniform Crime Reporting Program Offenses Known and Clearances by Arrest files 2013–2015 [29], following a previously used methodology for county-level aggregation [30]. We summed counts of crimes law enforcement identified as "actual" and not "unfounded," including murder, manslaughter, rape, robbery, assault, burglary, and larceny across multiple agencies for each month in every county and aggregated these to CBSAs. We excluded agencies with no associated FIPS code (0.01%) or underlying population (e.g. state parks, state-level agencies, 25%), those that did not report a full year of data (28.47%), and those whose jurisdiction spanned multiple counties (3%). Thus, our linked dataset is smaller than that of the main analysis (n = 989 versus 1060 counties), although at least one county in each included CBSA had adequate crime data.

2.5. Role of the funding source

NIH grant P30ES00002 to MGW supported conceptualization of the study.

3. Results

3.1. Descriptive findings

Among our primary analytic sample, there were a total of 7,709,300 live births in 520 included CBSAs with at least one fatality over the study period (Table 1). The highest number of police-related fatalities in one month was 11 in Los Angeles- Long Beach-Anaheim, California, which also had the most deaths over the study period (138 deaths) followed by Houston-Baytown-Sugar Land, TX (80 deaths),

Table 1
Characteristics of births and police killings in the 520 US Core-Based Statistical Areas [CBSAs] with at least one incident of fatal police violence during the study time period (2013–2015), overall and by number of police killings.

	Total	≤ 3 Police Killings	≥ 4 Police Killings
Births			
Total births			
N births	7,709,300	1,168,664	6,540,636
N CBSAs	520	336	184
Non-Hispanic White Women			
N births	3,885,565	763,832	3,121,733
N CBSAs	520	336	184
Hispanic Women			
N births	1,935,529	208,721	1,726,808
N CBSAs	520	336	184
Non-Hispanic Black Women			
N births	1,198,707	134,238	1,064,469
N CBSAs	520	336	184
Asian & Pacific Islander Women			
N births	573,339	38,130	535,209
N CBSAs	520	336	184
American Indian & Alaska Native			
Women	52,628	19,659	32,969
N births	496	314	182
N CBSAs			
Police Killings			
Total included deaths	2594	379	2215
Included causes of death			
Gunshot	2432	346	2086
Tasered	94	25	69
Beaten/Bludgeoned	20	1	19
Asphyxiated/Restrained	16	2	14
Stabbed	5	2	3
Chemical agent	4	0	4
Burned	4	1	3
Other	4	0	4
Undetermined	15	2	13
Race/ethnicity			
White	1119	221	898
Hispanic	427	35	392
Black	700	64	636
Asian & Pacific Islander	45	5	40
Middle Eastern	3	0	3
Native American	21	7	14
Missing	279	47	232

and Phoenix-Mesa-Scottsdale, AZ (77 deaths). Nearly 40% of CBSAs had only one incident of fatal police violence over the study period, and most months in most CBSAs had no fatalities. Of the births in our study, 50.5% lived in a CBSA with at least one incident of fatal police violence during the estimated month of conception. Our primary analysis included 2594 police-related fatalities, most of which (93.8%) were caused by gunshot.

3.2. Overall associations between fatal police violence and pregnancy loss

We find that each additional police-related fatality that occurred during the first month of gestation was associated with 0.14% fewer live births (Risk Ratio (RR): 0.9986; 95% Confidence Interval (CI): 0.9977, 0.9995), and that this association was strongest at the first estimated month of conception and moved gradually towards the null during the first through sixth gestational months (Fig. 1; numeric values in Supplementary Table 1). This association and pattern looked similar for CBSAs with high (≥4) numbers of fatalities over the study period, but confidence intervals included the null among CBSAs with low (≤3) fatalities (Supplementary Fig. 1). Only 15% of the births over the study period occurred in CBSAs with ≤3 police-related fatalities (Table 1), contributing to wider confidence intervals for these estimates compared to those in CBSAs with ≥4 fatalities. We estimated

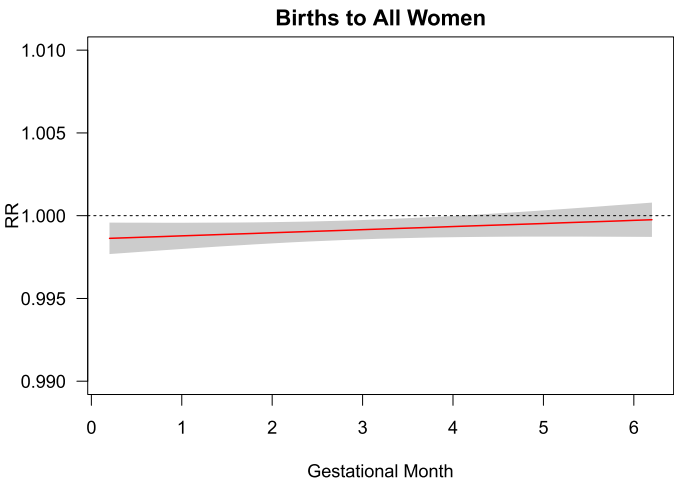

Fig. 1. Risk ratios and 95% confidence intervals for the association between each additional incident of fatal police violence in a month for the first six months of gestation and changes in live births in 520 U.S. core-based statistical areas 2013–2015.

Note: Model adjusted seasonality and the distributed lag was modeled using a natural spline with two degrees of freedom. The shaded areas represent 95% confidence intervals. Model estimated among 520 CBSAs with at least one incident of fatal police violence.

that exposure to 11 incidents of fatal police violence in the first month of pregnancy, as had occurred in the Los Angeles area, was associated with a 1.73% reduction in live births (95% CI: 0.85%, 2.61%).

3.3. Race-Stratified associations between fatal police violence and pregnancy loss

In models stratified by maternal race/ethnicity, we observed a statistically significant association between fatal police violence and changes in live births in models among Black, Asian, and Hispanic women, but not among White women (Fig. 2). For Black women, the association was strongest at sixth gestational month, each additional police-related fatality was associated with a 0.29% (95% CI: 0.11%, 0.48%) decrease in live births. Comparing race/ethnicity-stratified models that also stratified by ≥4 and ≤3 incidents of fatal police violence, results among CBSAs with ≤3 fatalities had wide confidence intervals that included the null across each racial/ethnic category except births to Hispanic women decreased by 2.26% for each additional police-related fatality in the first gestational month (95% CI: 0.52%, 3.97%) (Supplementary Fig. 2). In models among CBSAs with ≥4 fatalities, results were nearly identical to the maternal race/ethnicity-stratified models presented in Fig. 2 (Supplementary Fig. 2). Models that stratified by infant sex did not show meaningful differences across male and female births (Supplementary Fig. 4).

3.4. Race-Concordant associations between fatal police violence and pregnancy loss

We then estimated race concordant models that set the exposure to be fatalities of the same race/ethnicity for Black and White women, among 149 CBSAs that experienced ≥1 Black and ≥1 White police-related fatality over the study period (Fig. 3). The race-concordant association among White women, similar to the race stratified results, found no significant association between fatal police violence against White people and births to White women. Among Black women, the confidence intervals for the race-concordant association included the null. However, fatal police violence against Black people in the first through fourth month of gestation was associated with 0.34% fewer births to White women (Supplemental Fig. 3, 95% CI: 0.12–0.56%). Fatal police violence against White people was not associated with births to Black women (Supplementary Fig. 3).

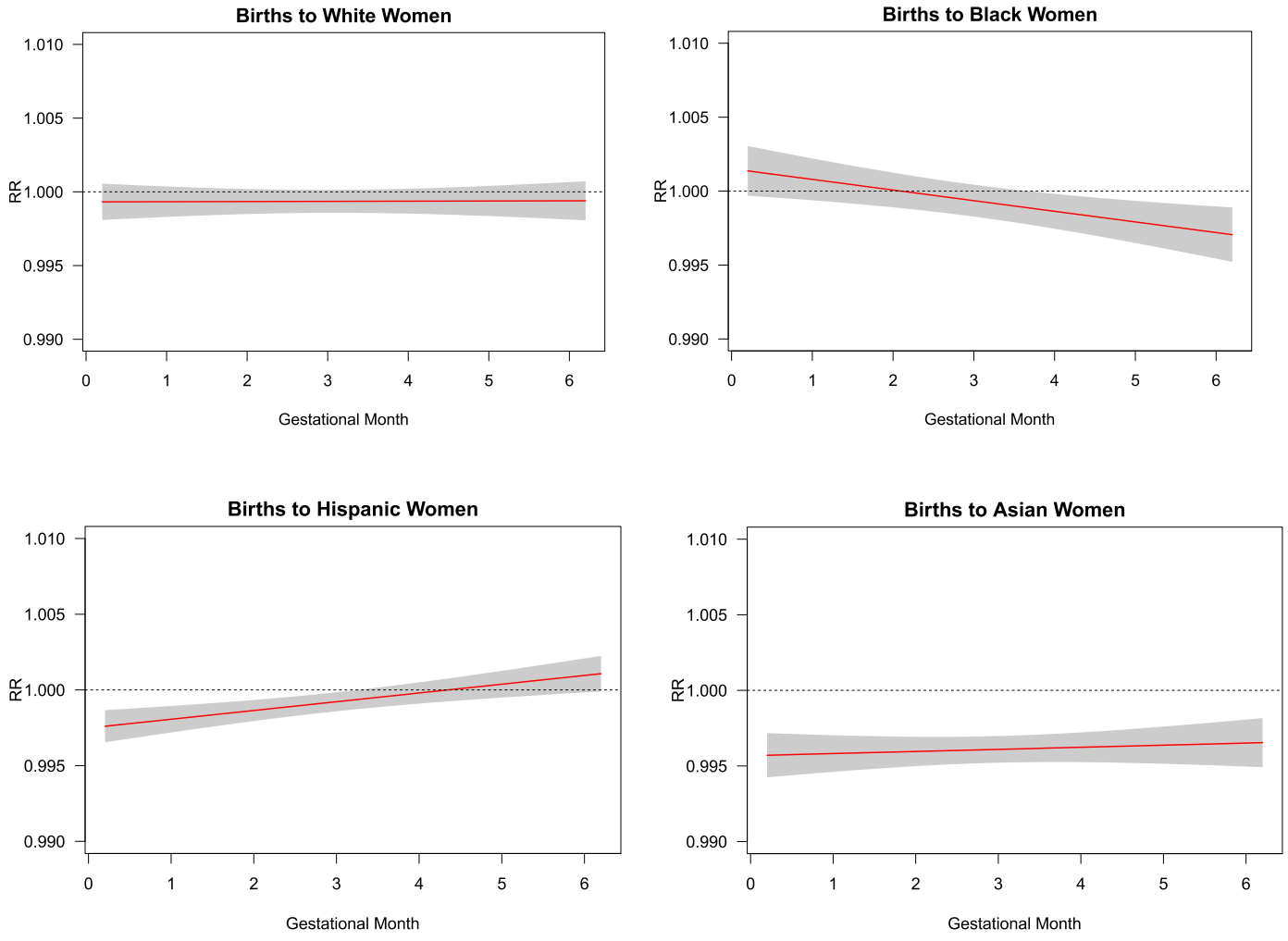

Fig. 2. Risk ratios and 95% confidence intervals for the association between each additional incident of fatal police violence in a month for the first six months of gestation and changes in live births in 520 U.S. core-based statistical areas 2013–2015, stratified by maternal race/ethnicity.

Note: Models adjusted seasonality and the distributed lag was modeled using a natural spline with two degrees of freedom. The shaded areas represent 95% confidence intervals. Models estimated among 520 CBSAs with at least one incident of fatal police violence.

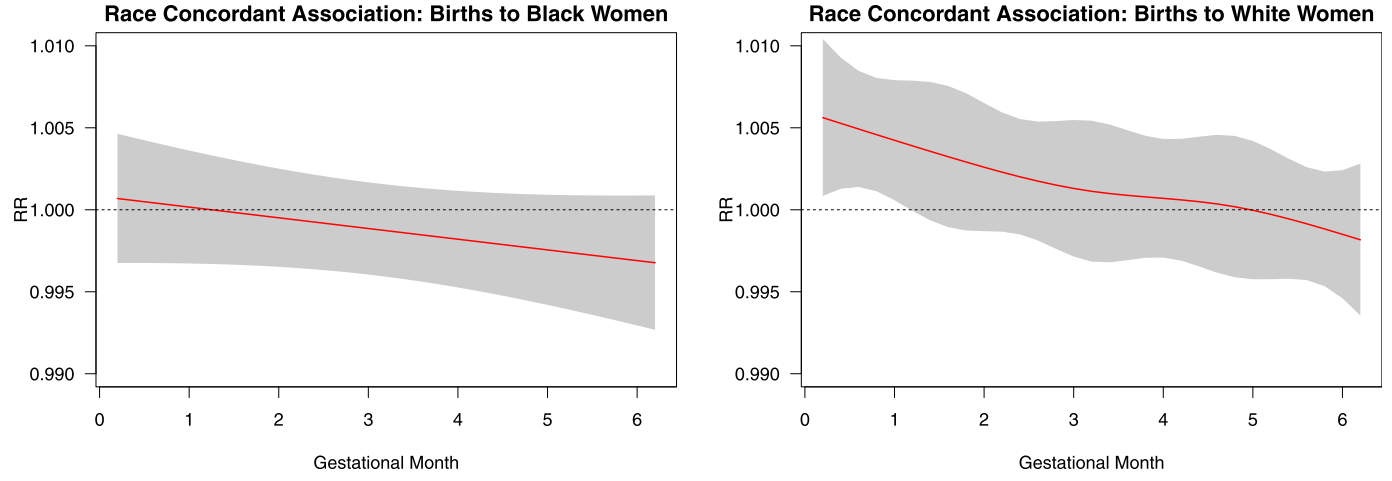

Fig. 3. Risk ratios and 95% confidence intervals for the association between each additional race concordant incident of fatal police violence in a month for the first six months of gestation and changes in live births to Black and White women in 520 U.S. core-based statistical areas 2013–2015, stratified by maternal race/ethnicity.

Note: Race concordant models estimate the association between fatal police violence against Black people with births to Black women, and police violence against White people and births to White women. Models adjusted seasonality and the distributed lag was modeled using a natural spline with five (white women) and two (Black women) degrees of freedom. The shaded areas represent 95% confidence intervals. Models were estimated among 149 CBSAs with at least 1 Black and 1 White incident of fatal police violence over the study period.

3.5. Sensitivity analyses

Lastly, we present results from our sensitivity analyses. We found that our findings were consistent in models that included a 9-month lag (Supplementary Fig. 5) and when we set the unit of analysis from CBSAs to counties (Supplementary Fig. 6). Associations were similar before and after adjustment for month-level crime across all models presented in the main analysis (Supplementary Fig. 7). Moreover, when we did not remove police-related deaths classified as "accidental", the results were very similar to the main models (Supplementary Fig. 8).

4. Discussion

Our analysis is the first to show a decrease in the number of live births, interpretable as pregnancy loss, associated with incidents of fatal police violence in both CBSAs and, in sensitivity analyses, counties. These results suggest fatal police violence has broad, population-level health consequences. Our conclusions are strengthened by our study design's control of time-invariant confounding and sensitivity analyses determining that results were robust to adjustment for month-level crime. Moreover, our national dataset of birth certificate records uniquely allowed for stratification across nearly all NCHS categories of race/ethnicity, which is important given distinct patterns of police surveillance across these racial/ethnic groups and that the data provided adequate sample sizes within most groups. An additional strength of our analysis is that findings were unchanged across different classifications of police violence (i.e. "accidental" versus "non-accidental") [31]. These contributions help illuminate the intergenerational effects of fatal police violence on communities.

Our finding that the negative association between fatal police and pregnancy loss occurred during the first two trimesters is consistent with previous research that suggests the early months of pregnancy may be particularly sensitive to psychosocial exposures [17]. Although many women may not know they are pregnant during these early gestational months, those aware of their pregnancy may experience psychologic distress related to pregnancy loss in addition to distress related to fatal police violence. That said, very little research has examined the adverse birth consequences of exposure to fatal police violence, and additional study of the mechanisms of biologic embodiment is needed.

Fatal police violence occurs within broader context of gendered racism that exposes Black, Hispanic and Native American women, their families, and communities, to disproportionate law enforcement surveillance. Our race-stratified analyses supported our hypotheses that fatal police violence acts as a racialized stressor for these groups, and aligns with prior research that has identified negative mental and physical health consequences of police violence [12,32,33]. We also found a negative association between fatal police violence against Black people and births to White women, as well as a negative association among Asian women, which indicates that population health impacts of fatal police violence may not be limited to racial/ethnic groups that are disproportionately affected. Our analysis was limited by available birth certificate data on ethnicity, language, and socioeconomic status, which prevented examination of important variation within the NCHS racial/ethnic classifications, given how these factors relate to police surveillance and perceptions of police [34]. Lastly, contrary to previous literature on fetal loss—which largely examined one-time, acutely stressful events and not repeated exposures[19]—we did not find a significant difference between male and female births. Previous research on antenatal depressive symptoms among Black women suggests the presence of young male children already in the household is an important factor in the psychosocial effects of anticipated police violence [11]. Our study was unable to examine potential effect modification by gender of other children in the household.

Our strongest association was among Hispanic women in CBSAs with ≤ 3 fatalities, which suggests fatal police violence in areas where these events are relatively rare have a particularly negative effect on the health of Latina women. Prior research that has identified negative health consequences of fatal police violence has focused on Black-White inequities given that the largest racial inequities in fatal police violence are between these groups [6]; our results suggest analyses for other racial/ethnic populations of color are warranted.

It should be noted too, that our estimated magnitude of effect is smaller than studies that have used a distributed lag modeling framework to estimate a decrease in live births for a 10 ppb increase in air pollution [25] ,although the units of exposure are difficult to compare and no previous analyses that implemented distributed lag modeling of pregnancy loss have examined continuous psychosocial exposures. CBSA fixed effects, although critical for confounding control, offer a very narrow definition for identifying an effect (i.e. changes within CBSAs). Thus, if incidents of fatal police violence occurred elsewhere in the state or across the nation [6], our models do not account for these additional exposures and would thus be biased towards the null. Similarly, our exposure data did not include information on court proceedings of cases involving police officers involved in fatal police violence, which may be similarly stressful as incidents of fatal police violence. Moreover, the available data only permitted month-level analysis, and a stronger association might exist at the week-level or at smaller geographic levels (e.g. census tract). We also had to assign day of birth, which contributed to non-differential misclassification of the exposure, particularly in the first and final gestational months. Lastly, our source of data on fatal police violence is sourced from media reports and public records. Although it is the most comprehensive dataset available, it is likely still missing deaths, which would bias our results towards the null. On the other hand, this bias is not likely to be strong given the hypothesized psychosocial pathways involved in pregnancy loss, women would more likely be affected by incidents of fatal police violence that they see through local news and social media.

Fatal police violence is an urgent area of public health attention, and public health researchers and practitioners have a role both in advocating for accurate data monitoring for these deaths and in continuing to document consequences for population health to inform policy and advocacy efforts. Fatal police violence and population health consequences are, in principle, preventable. The American Public Health Association put forward a policy statement in 2018 that suggests a primary prevention strategy that includes ending policing practices that criminalize marginalized experiences (e.g., immigration, homelessness, drug use and possession particularly among Black and Hispanic people) and investment in social determinants of health, including housing, education, employment, and mental health [5]. These changes require policy intervention at multiple levels and will require action by public health practitioners, researchers, activists and advocates, lawmakers, and law enforcement agencies.

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Authors' contributions

JLJ: conceptualization, data curation, formal analysis, investigation, project administration, visualization, writing.

NK: investigation, methodology, resources, supervision, writing— review & editing.

MA: investigation, supervision, writing— review & editing.

ML: formal analysis, investigation, methodology, writing— review & editing.

BAD: conceptualization, investigation, methodology, writing— review & editing.

MGW: conceptualization, investigation, funding acquisition, investigation, methodology, supervision, writing— review & editing.

JTC: conceptualization, investigation, funding acquisition, investigation, methodology supervision, writing— review & editing.

Data sharing statement

The restricted birth certificate microdata used in this study is available from the National Center for Health Statistics (NCHS). Access to these data requires research proposal review and approval from the NCHS. Fatal Encounters data are publicly available at fatalencounters.org.

Declaration of Competing Interest

The authors JLJ, NK, MA, ML, MAD, and JTC have nothing to disclose. MGW discloses funding from NIH.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2021.100901.

References

[1] Edwards F, Esposito MH, Lee H. Risk of police-involved death by race/ethnicity and place, United States, 2012–2018. Am J Public Health 2018;108:1241–8.
[2] Gelman A, Fagan J, Kiss A. An analysis of the New York City police department's "stop-and-frisk" policy in the context of claims of racial bias. J Am Stat Assoc 2007;102:813–23.
[3] Robinson Mock T, Jeannoel R, Gilmer R, Fuller C, Stahly-Butts M. End the war on black people: end the criminalization and dehumanization of black youth. Mov. Black Lives. https://policy.m4bl.org/end-war-on-black-people/ (accessed March 15, 2020).
[4] Krieger N. Measures of racism, sexism, heterosexism, and gender binarism for health equity research: from structural injustice to embodied harm-an ecosocial analysis. Annu Rev Public Health 2019 published online Nov 25. doi: 10.1146/annurev-publhealth-040119-094017.
[5] APHA Policy Statement Number 201811: Addressing law enforcement violence as a public health issue. 2018 https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2019/01/29/law-enforcement-violence (accessed Oct 12, 2019).
[6] Bor J, Venkataramani AS, Williams DR, Tsai AC. Police killings and their spillover effects on the mental health of black Americans: a population-based, quasi-experimental study. Lancet 2018;392:302–10.
[7] Hinton E. From the war on poverty to the war on crime: the making of mass incarceration in America. 1st Ed. Cambridge, MA: Harvard University Press; 2016.
[8] Hardeman RR, Medina EM, Kozhimannil KB. Structural racism and supporting black lives - the role of health professionals. N Engl J Med 2016;375:2113–5.
[9] Alang S, McAlpine D, McCreedy E, Hardeman R. Police brutality and black health: setting the agenda for public health scholars. Am J Public Health 2017;107:662–5.
[10] Williams DR. Stress and the mental health of populations of color: advancing our understanding of race-related stressors. J Health Soc Behav 2018;59:466–85.
[11] Jackson FM, James SA, Owens TC, Bryan AF. Anticipated negative police-youth encounters and depressive symptoms among pregnant African American women: a brief report. J Urban Health 2017;94:259–65.
[12] Yang N, Collins JW, Burris HH. States with more killings of unarmed black people have larger black–white preterm birth disparities. J Perinatol 2021(41):358–9.
[13] Hardeman R, Chantarat T, Karbeah J. Police exposure as a determinant of structural racism: an exploration of the association between preterm birth in neighborhoods with high police exposure. Health Serv Res 2020;55:50.
[14] Freedman AA, Borders A, Smart BP, et al. 18 Neighborhood police complaints associated with increased preterm delivery among black individuals. Am J Obstet Gynecol 2021;224:S13.
[15] Goin DE, Gomez AM, Farkas K, et al. Occurrence of fatal police violence during pregnancy and hazard of preterm birth in California. Paediatr Perinat Epidemiol 2021;00:1–10.
[16] Krieger N. Methods for the scientific study of discrimination and health: an ecosocial approach. Am J Public Health 2012;102:936–44.
[17] Parker VJ, Douglas AJ. Stress in early pregnancy: maternal neuro-endocrine-immune responses and effects. J Reprod Immunol 2010;85:86–92.
[18] Arck PC. Stress and pregnancy loss: role of immune mediators, hormones and neurotransmitters. Am J Reprod Immunol 2001;46:117–23.
[19] Bruckner TA, Catalano R, Ahern J. Male fetal loss in the U.S. following the terrorist attacks of September 11, 2001. BMC Public Health 2010;10:273.
[20] Centers for Disease Control and Prevention. User guide to the 2016 natality public use file. Centers for Disease Control and Prevention; 2016 ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/DVS/natality/UserGuide2016.pdf (accessed Feb 23, 2018).
[21] Fatal Encounters - Fatal Encounters. https://fatalencounters.org/(accessed March 1, 2020).
[22] Banks D, Ruddle P, Kennedy E, Planty MG. Arrest-related deaths program redesign study, 2015-2016: preliminary findings. 2016 https://www.bjs.gov/content/pub/pdf/ardprs1516pf.pdf (accessed Sept 25, 2019).
[23] US Census Bureau. Core-based statistical areas. https://www.census.gov/topics/housing/housing-patterns/about/core-based-statistical-areas.html (accessed Sept 10, 2020).
[24] Edwards F, Lee H, Esposito M. Risk of being killed by police use of force in the United States by age, race–ethnicity, and sex. Proc Natl Acad Sci 2019;116:16793–8.
[25] Kioumourtzoglou MA, Raz R, Wilson A, et al. Traffic-related air pollution and pregnancy loss. Epidemiology 2019;30:4–10.
[26] Cagnacci A, Renzi A, Arangino S, Alessandrini C, Volpe A. The male disadvantage and the seasonal rhythm of sex ratio at the time of conception. Hum Reprod 2003;18:885–7.
[27] Gasparrini A, Armstrong B, Scheipl F, Maintainer. package 'dlnm' title distributed lag non-linear models description collection of functions for distributed lag linear and non-linear models. 2019.
[28] Messer LC, Kaufman JS, Dole N, Savitz DA, Laraia BA. Neighborhood crime, deprivation, and preterm birth. Ann Epidemiol 2006;16:455–62.
[29] Uniform Crime Reporting Program Data: Offenses known and clearances by arrest, United States, 2013-2015. 2013 https://www.icpsr.umich.edu/icpsrweb/NACJD/studies/37061 (accessed Feb 14, 2020).
[30] Bondurant SR, Lindo JM, Swensen ID. Substance abuse treatment centers and local crime. J Urban Econ 2018;104:124–33.
[31] Bor J, Venkataramani AS, Williams DR, Tsai AC. Validity of details in databases logging police killings – AUTHORS' reply. Lancet 2019;393:1413.
[32] Sewell AA, Jefferson KA. Collateral damage: the health effects of invasive police encounters in New York City. J Urban Health 2016;93(1):42–67 Suppl.
[33] Sewell AA, Feldman JM, Ray R, Gilbert KL, Jefferson KA, Lee H. Illness spillovers of lethal police violence: the significance of gendered marginalization. Ethn Racial Stud 2020;44(7):1089–114.
[34] Sun IY, Wu Y, Sun IY, Wu Y. Race, immigration, and social control. UK: Palgrave Macmillan; 2018. p. 1–7.