Title: Economic Downturns and Inequities in Birth Outcomes: Evidence from 148 Million US Births

Paper submitted for 2019 PAA Annual Meeting in Austin, TX

Authors: Clemens Noelke[1,*], Yu-Han Chen[1], Teresa Osypuk[2], Dolores Acevedo-Garcia[1]

***Correspondence to:** Dr. Clemens Noelke
Institute for Child, Youth, and Family Policy
Heller School for Social Policy and Management
Brandeis University
415 South Street, MS 035
Waltham, MA 02453
Phone: 781-736-8748
Email: cnoelke@brandeis.edu

Author Affiliations: [1]Heller School for Social Policy and Administration, Brandeis University, Waltham, MA; [2]Division of Epidemiology and Community Health, School of Public Health, University of Minnesota, Minneapolis, MN.

Funding: This work was supported by grants from the Robert Wood Johnson Foundation and the WK Kellogg Foundation.

Conflict of Interest: None declared.

Human Participant Protection: This study was approved by the Brandeis University Committee for Protection of Human Subjects, IRB Protocol #18008.

Economic Downturns and Inequities in Birth Outcomes: Evidence from 148 Million US Births

Using birth certificate data for nearly all registered US births over the past 40 years (1977 to 2016) and monthly data on state unemployment rates, this study reexamines the link between macroeconomic variation and birth outcomes, with a particular focus on variation in the effect of unemployment over time and by maternal race and education. Using fixed-effect regression models, we find that a one percentage point increase in state unemployment during the first trimester of pregnancy increases the probability of preterm by 0.1 percentage points, while increases in the state unemployment rate during the second and third trimester reduce the probability of PTB by 0.05 percentage points. During the period encompassing the Great Recession, these effects double in size. Over the entire observation period, we find that less educated, black, and black and less educated women are more vulnerable to the business cycle. For less educated, and black and less educated mothers, this vulnerability is further increased during the most recent period covering the Great Recession. The results highlight the increased relevance of economic conditions for birth outcomes and population health as well as continuing, large inequities in the exposure and impact of macro-economic fluctuations on birth outcomes.

Word Count Paper: 3,058

Word Count Abstract: 198

Keywords: birth outcomes, business cycles, racial/ethnic inequities, recessions

Abbreviations: LBW, low birth weight; PTB, preterm birth; SGA, small for gestational age

Capitalist economies experience constant change in macroeconomic conditions, which generates exogenous variation in economic and other health-related exposures. A growing number of studies has sought to clarify how these operational risks of capitalism are linked to population health (1–9), but research on the link between macroeconomic conditions and birth outcomes requires further clarification. Three earlier studies have found newborn health to improve during economic downturns (10–12), but a recent study found increased risks of preterm birth (PTB) during downturns experienced in the first trimester and decreased risk of PTB for downturns experienced in the second trimester of pregnancy (13). Earlier studies find substantial variation in the impact of economic conditions by maternal race (10, 11), while the latter finds none (13).

Protective effects reported by earlier studies (10–12) are likely due to a reduction in economic activity, work hours, and pollution during downturns (14–17), which reduce pregnant women's exposure to certain toxic stressors. Ambient air pollution, which increases the risk of adverse birth outcomes (18–21), declines during economic downturns (16, 17, 22). Both physical work and work-related psychosocial stress have been linked to adverse birth outcomes (23–25), and by reducing work hours, pregnant women's exposure to work-related stressors may decline during recessions.

Because racial/ethnic minority and low socio-economic status are associated with increased exposure to environmental hazards and air pollution (26–30), we expect economic downturns to have stronger effects on black and less educated women. Similarly, low education and racial/ethnic minority status increase the risk of working in unsafe/hazardous working conditions, including intense physical work, exposure to toxic substances, discrimination, and harassment (24, 31–33). These inequities in toxic exposures should magnify the protective

impact of economic downturns among less educated and black women, as found in previous studies (10, 11).

However, other research suggests that recessions have adverse effects on newborn health (34, 35). One study found that downturns experienced during the first trimester increase the risk of PTB while second trimester downturns decrease the risk of PTB (13). Hazardous first trimester effects may be due to increased exposure to (or perceived risk of) adverse financial and economic events that occur with greater frequency during recessions: loss of employment, income, assets (homes), and social status (14, 15, 36, 37). Again, less educated and black women should be more affected. Both are at an increased risk of job loss (36, 38) and, because of lower wealth, more pre-existing health conditions, and lower access to quality health care (39–41), more likely to experience health declines in response to economic shocks.

Our study period encompasses the labor market downturn and recovery related to the Great Recession, during which we expect the effect of economic conditions to be amplified. Unlike other downturns in our 40-year study period or since the Great Depression, the labor market downturn during the Great Recession was exceptionally deep, long-lasting, and flanked by a historic decline in household assets (14, 15, 44). These conditions should combine to magnify the impact of economic conditions on birth outcomes, especially for economically more vulnerable groups.

METHODS

Data

Data files on birth outcomes come from the National Center for Health Statistics and are based on birth certificates for all registered births occurring in the US from 1977 to 2016. Using information on gestational age, we estimate the month of conception and include all births that resulted from conceptions between January 1977 and March 2016 for mothers reporting to be residents of one of the 50 US states or DC, 151,066,057 in total. We exclude births to mothers aged less than 15 or older than 46 years, with missing information on race, birth weight, or gestational age, and births with implausible combinations of gestational age and birth weight (42). The resulting dataset includes 147,992,404 births. This study was approved by the Brandeis University Human Research Protection Program for the protection of human subjects (IRB Protocol #18008).

Outcomes

Gestational age is reported in weeks, based on either the last menstrual period or an obstetric/clinical estimate if available. We estimate month of conception by subtracting gestational age (converted to months and rounded to the nearest integer) from the calendar month of birth. We define preterm births (PTB) as births occurring before the 37th week of gestation (vs. after) and low birth weight (LBW) births as babies weighing less than 2,500 grams (vs. higher). A newborn is classified small-for-gestational age (SGA) if weighing less than the 10th percentile of their sex- and plurality-specific (single vs. multiple) birth weight distribution for a given gestational age in weeks (vs. greater) (43).

Economic conditions

We use seasonally adjusted, monthly state unemployment rates as the primary measure of macroeconomic conditions (Bureau of Labor Statistics, "Employment status of the civilian non-institutional population, seasonally adjusted" series). Previous research suggests that state-level measures of economic conditions have larger effects on birth outcomes compared to county-level measures (12). For sensitivity analysis, we used monthly employment-population ratios (100 times the number of employed divided by the population), which produced qualitatively similar results, but smaller coefficient estimates.

Modifiers

Maternal race is measured using three categories: African American, other and white. Hispanic origin cannot be consistently distinguished over the observation period. Maternal education is measured using four levels: Less than high school (0-11 years of education), high school (12 years), some college (13-15 years), and college or higher (16+ years).

We conduct separate analyses for the most recent 10 years covering the Great Recession, i.e., all conceptions between January 2006 and March 2016. While the NBER Business Cycle Committee dates the Great Recession from December 2007 to June 2009, the labor market downturn persisted well beyond the official end date. Both downturn and following boom provide exceptional variation in economic conditions that helps us understand how this unique economic period in recent history has affected newborn health and what the association between economic conditions and birth outcomes looks like in most recent data. Previous work also shows that effects of macroeconomic conditions on health outcomes become unstable if estimated over very short periods (8).

Other covariates

Other covariates include: maternal age in years (15-17, 18-24, 25-35, 36-46), nativity (US- or foreign-born), live birth order (first, second, third, or four or more births), and infant's sex (male, female).

ESTIMATION

Estimation is performed using grouped data, where each cell is defined by all existing combinations of values of the variables analyzed, using the number of births in each cell as frequency weights. We mainly rely on linear probability models estimated via Ordinary Least Squares, which is computationally efficient given the large number of observations and parameters we fit and yields estimates that have an intuitive interpretation, revealing the magnitude of effects in absolute terms. Analysis was performed in Stata 14 (MP) using the reghdfe ado (44). Results using logistic regression are reported in the Appendix. Our baseline model for individual birth outcomes takes the following form:

1. $P(Y = 1)_{ijt} = \beta_1 Pre_{jt} + \beta_2 First_{jt} + \beta_3 SecondThird_{jt} + \alpha_j + \theta_t + \delta_j T + \boldsymbol{X\gamma} + \varepsilon_{ijt}$

where i individuals, j indexes 51 states of maternal residence and t indexes calendar months (month of conception) from January 1977 to March 2016. $P(Y = 1)$ is the probability of an adverse birth outcome. α_j are 51 state fixed effects, θ_t are 470 monthly calendar date fixed effects, and $\delta_j T$ are 51 state-specific linear trends, i.e., interactions between state fixed effects and a linear trend variable with $T = 1, \ldots, 471$. $\boldsymbol{X\gamma}$ is a matrix of covariates and its coefficient vector, included only in some sensitivity analyses.

We separately model economic conditions prior to conception, and in the first and second/third trimesters. We include the average unemployment rate over the period from three months prior to the month prior to conception, Pre_{jt}, to control for selection effects. Our main focus is on the average unemployment rate from the month of conception to the end of the first trimester, $First_{jt}$, and the average unemployment rate for the second and third trimester, $SecondThird_{jt}$. Not all pregnancies are carried to term so that the second/third trimester economic measures partially capture economic conditions after birth, introducing measurement error for some births. We repeated the analysis using average conditions in the second trimester only, which did not alter results.

Equation 1 identifies the effect of economic conditions by comparing babies conceived in the same calendar month, but different states and under different state-specific economic conditions, exploiting variation in economic conditions across 24,021 state-by-calendar month contexts. State fixed effects, α_j, control for unobserved confounders that are state-specific and time constant. The θ_t calendar month of conception fixed effects control for secular change in the outcome variable over time, including seasonal factors. State-specific linear trends, $\delta_j T$, control for time-varying state-level variables that could confound the association between economic conditions and birth outcomes.

Equation 1 differs from the empirical models in previous work (13). Instead of calendar month of conception, θ_t, Margerison-Zilko et al. (13) controlled for year of conception and month of birth. Month of conception controls for the effect of unobserved maternal characteristics that predict newborn health (45) and are confounded with economic conditions because of selective conceptions/terminations. In the Appendix, we show that omitting month of

conception likely introduces omitted variable bias in trimester-specific unemployment rate estimates, substantially inflating the size of effect estimates.

Robustness checks

Instead of state-specific linear trends, we add the full set of interactions between state and year of conception fixed effects (2,040 parameters), controlling non-parametrically for year-to-year change in unobserved confounders at the state-level, such as state-specific year-to-year changes in health of mothers, socioeconomic conditions, and policies. To adjust for selection effects either prior to or during pregnancy, we adjust for individual covariates that are fixed at conception. These covariates, $\boldsymbol{X\gamma}$, enter either linearly or fully interacted, i.e., all possible interactions between all covariate levels (1,426 parameters). While this may partially adjust for selection, the covariate distribution at birth is determined by partly unobserved selection processes and adjusting for selected covariate values can induce rather than eliminate bias. These results should therefore be interpreted with some caution.

Statistical inference

We report 95% confidence intervals that are corrected for clustering of observations at the state level (46). Because our data includes nearly all registered birth over the past 40 years, we focus interpretation on the magnitude rather than statistical significance of effect estimates.

RESULTS

Table 1 presents summary statistics for all birth outcomes and modifiers/covariates used in the analyses. Table 2 presents descriptive statistics for the main exposure variable, monthly

state unemployment rates. We report statistics for the full study period and the period encompassing the Great Recession.

Table 3 shows estimates of the effect of average state unemployment rates prior and during pregnancy on three birth outcomes. Across covariate different specifications, first trimester unemployment is positively associated with the probability of preterm birth. The effect is robust to controls for state-level, time-varying confounders (Models 2 and 3 vs. 1) and increase in magnitude after conditioning on maternal/babies' characteristics (Models 4 and 5), suggesting that the hazardous first-trimester effect estimates may be biased downward due to elective/spontaneous terminations in the first trimester. Furthermore, we find that second/third trimester unemployment rates are negatively associated with the probability of preterm birth. Effect estimates are sensitive to controlling for state-level, time-varying confounders (Models 2 and 3 vs. 1), but invariant to conditioning on maternal/babies' characteristics.

Model 2 is our preferred specification, yielding results similar to Model 3 using much fewer parameters. The respective estimates indicate that a one percentage point increase in state unemployment rates during the first trimester increases the probability of PTB by 0.1 percentage points. In 2016, this would translate into approximately 4,000 more babies born preterm, or 1% of all babies born preterm in that year. Economic downturns during the second/third trimester are weakly protective: a one percentage point increase in state unemployment rates during the second/third trimester would decrease the probability of PTB by 0.05 percentage points. These effects are substantially smaller than previous research (13) has reported (see Appendix).

[Table 3 here]

Estimates of the impact of unemployment rates during pregnancy on LBW and SGA are sensitive to changes in model specification. Fully adjusted models (Models 4 and 5) provide no evidence of meaningful effects, indicating that economic conditions during pregnancy affect primarily the timing of birth.

Table 4 reports results for population subgroups and by period. Results in the top panel are based on births over the period from 1977 to 2016, while results in the bottom panel focus on the most recent ten years for which data is available, covering the Great Recession and subsequent recovery (2006-2016). All estimates are based on the baseline model specification (equation 1), excluding controls for maternal/babies' characteristics. The first column reports results for births to all mothers. Columns 2, 3, and 4 report results for births to black mothers, mothers with a high school degree or less education, and mothers who are both black and have no more than a high school degree.

[Table 4 here]

For the full observation period, we find larger effects for both first and second/third trimester unemployment on PTB among black mothers and less educated mothers compared to the population of all mothers. Estimates are largest for mothers who are both less educated and black, for whom a one percentage point increase in first trimester (second/third trimester) unemployment rates is associated with a 0.3 percentage point increase (0.1 percentage point decrease) in the probability of preterm birth, which is roughly three times the size as the average effect for all mothers.

Compared to the full observation period (top panel), estimates of first and second/third trimester unemployment are magnified in most recent data (bottom panel) for all mothers, less

educated mothers, and black mothers with less education. For all mothers, a one percentage point increase in first trimester unemployment rates increases the probability of PTB by 0.19 percentage points. In absolute terms and using 2016 data, a one percentage point increase in state unemployment rates would result in 7,300 additional babies born preterm, while a five percentage point increase, as observed nationally during the Great Recession, would result in approximately 36,500 babies born preterm, or 9% of all preterm births in 2016.

For black women with a high school degree or less, the same increase in unemployment rates would increase the probability of PTB by 0.35 percentage, which is nearly twice the size compared to the effect for all mothers. For PTB, the protective second/third trimester effects are similarly larger among black and less educated women in the full dataset, and also increase during the Great Recession. For white women and women with higher education, estimated effects are close to what we observe for the general population (Appendix Table A3).

Over the entire observation period, both first and second/third trimester effects of downturns are weakly protective for SGA and LBW. In the most recent period, we observe hazardous effects of first trimester increases in unemployment and protective effects of second/third trimester unemployment increases for LBW, with largest effects among less educated, black, and less educated and black mothers. However, effects are smaller than what we observe for PTB. For SGA, effect sizes are small even during the Great Recession and differ in sign across population groups.

DISCUSSION

Using data on nearly all registered births over the period from 1977 to 2016, we find that a one percentage point increase in state unemployment during the first trimester of pregnancy

increases the probability of PTB by 0.1 percentage points, while increases in the state unemployment rate during the second and third trimester reduce the probability of PTB by 0.05 percentage points. During the period encompassing the Great Recession, these effects double in size, and we also observe similar effects for LBW, though not for SGA. In combination, these findings suggest that economic conditions primarily affect the timing of birth, though during the Great Recession we also observe effects on LBW. Furthermore, over the entire observation period and during the period encompassing the Great Recession, we find evidence that less educated, black, and black and less educated women are more vulnerable to the business cycle.

First-trimester exposure to socio-economic stress could lead to spontaneous abortion of frail fetuses, resulting in positive selection among fetuses surviving the first trimester. The protective effects of second/third semester downturns could therefore be due to a selection effect (13). Consistent with this explanation, we found first trimester effects on PTB to increase after controlling for maternal/babies' characteristics. However, second/third trimester effects remained essentially unchanged, which does not support the selection explanation. A previous study found both first and second trimester effects to be robust to adjusting for maternal/babies' characteristics (13).

If not selection, the reversal of the impact of economic conditions from hazardous to protective may reflect that women's vulnerability to external stressors may change over the course of pregnancy. On the one hand, previous research suggest that both women's emotional responses to life events and the physiological stress response to psychosocial stressors become attenuated over the course of pregnancy (47, 48). On the other hand, the impact of pollution on birth outcomes appears to be constant across trimesters of pregnancy (23–25). If the effect of increased exposure to adverse economic/financial shocks weakens while the effect to decreased

exposure to pollution and other stressors remains constant over the course of pregnancy, this may explain why we observe a net hazardous effect of downturns early in pregnancy but net protective effects later on.

A limitation of our study is that our estimated dates of conception and length of gestation are likely affected by measurement error, which could introduce attenuation bias in our unemployment rate estimates. Furthermore, the trimester-specific effects we estimate are average effects estimates across all pregnant women, regardless of whether and how they were affected by business cycle-related exposures. Failing to distinguish women who experience downturns as protective (vs. hazardous), we obtain an average effect estimate that likely masks considerable heterogeneity in individual level effects. More detailed socio-economic information would allow future research to better pinpoint the subgroups affected in different ways and isolate the underlying mechanisms.

At the same, our analysis has uncovered evidence of variation in the impact of the business cycle across population subgroups. Reflecting broader patterns of inequality in American society, we found that less educated and black women are particularly vulnerable to the business cycle. Moreover, we discovered that the intersection of both sources of disadvantage is associated with the greatest susceptibility, and that these inequities were further magnified during the Great Recession.

REFERENCES

1. Brenner M. Mortality and the national economy: a review, and the experience of England and Wales, 1936-76. *The Lancet*. 1979;314(8142):568–573.
2. Ruhm CJ. Are recessions good for your health? *Q. J. Econ.* 2000;115(2):617–650.
3. Tapia Granados JA, House JS, Ionides EL, et al. Individual joblessness, contextual unemployment, and mortality risk. *Am. J. Epidemiol.* 2014;180(3):280–287.
4. Cylus J, Glymour MM, Avendano M. Do generous unemployment benefit programs reduce suicide rates? A state fixed-effect analysis covering 1968-2008. *Am. J. Epidemiol.* 2014;180(1):45–52.
5. Catalano R, Goldman-Mellor S, Saxton K, et al. The health effects of economic decline. *Annu. Rev. Public Health*. 2011;32:431–450.
6. Cutler DM, Huang W, Lleras-Muney A. Economic conditions and mortality: evidence from 200 years of data. National Bureau of Economic Research Working Paper 22690. Cambridge, MA: National Bureau of Economic Research; 2016.
7. Avendano M, Berkman LF. Labor markets, employment policies and health. In: Berkman LF, Kawachi I, Glymour M, eds. *Social epidemiology*. Oxford, UK: Oxford University Press; 2014:182–233.
8. Ruhm CJ. Recessions, healthy no more? National Bureau of Economic Research Working Paper 19287. Cambridge, MA: National Bureau of Economic Research; 2013.
9. Tapia Granados JA. Increasing mortality during the expansions of the US economy, 1900–1996. *Int. J. Epidemiol.* 2005;34(6):1194–1202.
10. Dehejia R, Lleras-Muney A. Booms, busts, and babies' health. *Q. J. Econ.* 2004;119(3):1091–1130.

11. Orsini C, Avendano M. Macro-economic conditions and infant health: a changing relationship for black and white infants in the United States. *PloS One*. 2015;10(5):e0123501.
12. Lindo JM. Aggregation and the estimated effects of economic conditions on health. *J. Health Econ.* 2015;40:83–96.
13. Margerison-Zilko CE, Li Y, Luo Z. Economic conditions during pregnancy and adverse birth outcomes among singleton live births in the United States, 1990-2013. *Am. J. Epidemiol.* 2017;186(10):1131–1139.
14. Elsby MWL, Hobijn B, Sahin A. The labor market in the Great Recession. *Brook. Pap. Econ. Act.* 2010;41(1):1–69.
15. Kalleberg AL, von Wachter T. The u.s. labor market during and after the Great Recession: continuities and transformations. *RSF*. 2017;3(3):1–19.
16. Davis ME. Recessions and health: the impact of economic trends on air pollution in California. *Am. J. Public Health*. 2012;102(10):1951–1956.
17. Heutel G, Ruhm CJ. Air pollution and procyclical mortality. National Bureau of Economic Research Working Paper 18959. Cambridge, MA: National Bureau of Economic Research; 2013.
18. Warren JL, Son J-Y, Pereira G, et al. Investigating the impact of maternal residential mobility on identifying critical windows of susceptibility to ambient air pollution during pregnancy. *Am. J. Epidemiol.* 2018;187(5):992–1000.
19. Ghosh JKC, Wilhelm M, Su J, et al. Assessing the influence of traffic-related air pollution on risk of term low birth weight on the basis of land-use-based regression models and measures of air toxics. *Am. J. Epidemiol.* 2012;175(12):1262–1274.

20. Padula AM, Mortimer K, Hubbard A, et al. Exposure to traffic-related air pollution during pregnancy and term low birth weight: estimation of causal associations in a semiparametric model. *Am. J. Epidemiol.* 2012;176(9):815–824.

21. Nieuwenhuijsen MJ, Dadvand P, Grellier J, et al. Environmental risk factors of pregnancy outcomes: a summary of recent meta-analyses of epidemiological studies. *Environ. Health*. 2013;12:6.

22. Knight KW, Rosa EA, Schor JB. Could working less reduce pressures on the environment? A cross-national panel analysis of OECD countries, 1970–2007. *Glob. Environ. Change*. 2013;23(4):691–700.

23. Lee B-E, Ha M, Park H, et al. Psychosocial work stress during pregnancy and birthweight. *Paediatr. Perinat. Epidemiol.* 2011;25(3):246–254.

24. Lee LJ, Symanski E, Lupo PJ, et al. Data linkage between the National Birth Defects Prevention Study and the Occupational Information Network (O*NET) to assess workplace physical activity, sedentary behaviors, and emotional stressors during pregnancy. *Am. J. Ind. Med.* 2016;59(2):137–149.

25. Katz VL. Work and work-related stress in pregnancy. *Clin. Obstet. Gynecol.* 2012;55(3):765–773.

26. Pais J, Crowder K, Downey L. Unequal trajectories: racial and class differences in residential exposure to industrial hazard. *Soc. Forces*. 2014;92(3):1189–1215.

27. Crowder K, Downey L. Inter-neighborhood migration, race, and environmental hazards: modeling micro-level processes of environmental inequality. *Am. J. Sociol.* 2010;115(4):1110–1149.

28. Hajat A, Diez-Roux AV, Adar SD, et al. Air pollution and individual and neighborhood socioeconomic status: evidence from the multi-ethnic study of atherosclerosis (MESA). *Environ. Health Perspect.* 2013;121(11–12):1325–1333.

29. Brulle RJ, Pellow DN. Environmental justice: human health and environmental inequalities. *Annu. Rev. Public Health*. 2006;27:103–124.

30. Pastor M, Morello-Frosch R, Sadd JL. The air is always cleaner on the other side: race, space, and ambient air toxics exposures in California. *J. Urban Aff.* 27(2):127–148.

31. Maestas N, Mullen KJ, Powell D, et al. Working conditions in the United States: results of the 2015 American Working Conditions Survey. Santa Monica, CA: RAND Corporation: 2017.

32. Okechukwu CA, Souza K, Davis KD, et al. Discrimination, harassment, abuse, and bullying in the workplace: contribution of workplace injustice to occupational health disparities. *Am. J. Ind. Med.* 2014;57(5):573–586.

33. Lipscomb HJ, Loomis D, McDonald MA, et al. A conceptual model of work and health disparities in the United States. *Int. J. Health Serv.* 2006;36(1):25–50.

34. Margerison-Zilko CE, Catalano R, Hubbard A, et al. Maternal exposure to unexpected economic contraction and birth weight for gestational age. *Epidemiol. Camb. Mass*. 2011;22(6):855–858.

35. Carlson K. Fear itself: The effects of distressing economic news on birth outcomes. *J. Health Econ.* 2015;41:117–132.

36. Farber HS. Job loss in the great recession: historical perspective from the displaced workers survey, 1984-2010. National Bureau of Economic Research Working Paper 17040. Cambridge, MA: National Bureau of Economic Research; 2011.

37. Burgard SA, Ailshire JA, Kalousova L. The great recession and health: people, populations, and disparities. *Ann. Am. Acad. Pol. Soc. Sci.* 2013;650(1):194–213.

38. Hoynes H, Miller DL, Schaller J. Who suffers during recessions? *J. Econ. Perspect.* 2012;26(3):27–48.

39. Shapiro T, Meschede T, Osoro S. The roots of the widening racial wealth gap: explaining the black-white economic divide. Institute on Assets and Social Policy Research and Policy Brief, Heller School for Social Policy and Management, Brandeis University: 2013.

40. Wolff EN. Household wealth trends in the United States, 1962-2013: what happened over the Great Recession? National Bureau of Economic Research Working Paper 20733. Cambridge, MA: National Bureau of Economic Research; 2014.

41. Williams DR, Mohammed SA, Leavell J, et al. Race, socioeconomic status, and health: complexities, ongoing challenges, and research opportunities. *Ann. N. Y. Acad. Sci.* 2010;1186:69–101.

42. Alexander GR, Himes JH, Kaufman RB, et al. A United States national reference for fetal growth. *Obstet. Gynecol.* 1996;87(2):163–168.

43. Elo IT, Culhane JF, Kohler IV, et al. Neighbourhood deprivation and small-for-gestational-age term births in the United States. *Paediatr. Perinat. Epidemiol.* 2009;23(1):87–96.

44. Correia S. reghdfe: Stata module for linear and instrumental-variable/GMM regression absorbing multiple levels of fixed effects. Statistical Software Components s457874. Boston, MA: Boston College Department of Economics; 2017. https://ideas.repec.org/c/boc/bocode/s457874.html. Accessed August 12, 2018.

45. Buckles KS, Hungerman DM. Season of birth and later outcomes: old questions, new answers. *Rev. Econ. Stat.* 2013;95(3):711–724.

46. Bertrand M, Duflo E, Mullainathan S. How much should we trust differences-in-differences Estimates? *Q. J. Econ.* 2004;119(1):249–75.

47. Glynn LM, Schetter CD, Wadhwa PD, et al. Pregnancy affects appraisal of negative life events. *J. Psychosom. Res.* 2004;56(1):47–52.

48. Entringer S, Buss C, Shirtcliff EA, et al. Attenuation of maternal psychophysiological stress responses and the maternal cortisol awakening response over the course of human pregnancy. *Stress Amst. Neth.* 2010;13(3):258–268.

TABLES

Table 1. Descriptive Statistics for Births Used in Multivariate Analysis. Registered Births to United States Residents Conceived in the Period from January 1977 to March 2016 and January 2006 to March 2016 from National Center for Health Statistics Natality Files.

Variables	1977 – 2016		2006 – 2016	
	Births	%	Births	%
Sample size	147,992,404	100.00	41,209,568	100.00
Outcomes				
Preterm birth	15,812,440	10.68	4,737,908	11.50
Low birth weight	10,953,293	7.40	3,339,135	8.10
Small for gestational age	15,316,822	10.35	4,283,812	10.40
Maternal race				
Black	23,061,622	15.58	6,579,977	15.97
Other	8,264,894	5.58	3,181,410	7.72
White	116,665,888	78.83	31,448,181	76.31
Maternal education				
Less than high school (0-11 years)	27,778,459	18.77	6,540,581	15.87
High school (12 years)	44,953,390	30.38	9,614,716	23.33
Some college (13-15 years)	30,878,294	20.86	10,240,540	24.85
College or more (16+ years)	30,883,739	20.87	10,550,580	25.60
Missing	13,498,522	9.12	4,263,151	10.35
Nativity				
Native-born	119,962,564	81.06	31,432,094	76.27
Foreign-born	27,530,857	18.60	9,515,342	23.09
Missing	498,983	0.34	262,132	0.64
Maternal age (years)				
15-17	5,582,437	3.77	975,718	2.37
18-24	49,656,349	33.55	11,947,695	28.99
25-35	80,120,312	54.14	23,553,333	57.16
36+	12,633,306	8.54	4,732,822	11.48
Live birth order				
First	59,890,621	40.47	16,266,408	39.47
Second	47,668,191	32.21	13,027,892	31.61
Third	24,060,268	16.26	6,860,737	16.65
Fourth or more	16,079,571	10.87	5,054,531	12.27
Missing	293,753	0.20	0	0
Infant’s sex				
Male	72,262,278	48.83	20,129,595	48.85
Female	75,730,126	51.17	21,079,973	51.15
Plurality				
Single	143,823,101	97.18	39,797,193	96.57
Twins or more	4,169,303	2.82	1,412,375	3.43

Table 2. Descriptive Statistics for Monthly State Unemployment Rate Variables Used in Multivariate Analysis. January 1977 to March 2016 and January 2006 to March 2016.

	Minimum	25th Percentile	50th Percentile	75th Percentile	Maximum
January 1977 to March 2016	2.26	4.95	6.03	7.48	18.09
January 2006 to March 2016	2.51	5.02	6.57	8.37	14.04

Table 3. Effect of State Unemployment Around the Time of Conception and During Pregnancy on the Probability of PTB, LBW, and SGA. National Center for Health Statistics Natality Files, All Registered Births to US Residents Conceived in the Period from January 1977 to March 2016. OLS Linear Probability Estimates, multiplied by 100, and Robust 95% Confidence Intervals.

Variables	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]		Model 5[e]	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Preterm birth										
1-3 months prior to conception	-0.092	-0.156, -0.028	-0.070	-0.110, -0.030	-0.054	-0.083, -0.025	-0.080	-0.114, -0.046	-0.080	-0.114, -0.046
Conception to 1st trimester	0.095	0.058, 0.132	0.099	0.060, 0.138	0.100	0.058, 0.141	0.141	0.087, 0.195	0.142	0.088, 0.196
2nd to end of 3rd trimester	-0.109	-0.147, -0.070	-0.053	-0.090, -0.016	-0.048	-0.106, 0.011	-0.055	-0.108, -0.002	-0.056	-0.109, -0.003
Low birth weight										
1-3 months prior to conception	0.013	-0.015, 0.041	0.019	-0.003, 0.040	0.037	0.005, 0.069	0.016	-0.009, 0.041	0.015	-0.010, 0.040
Conception to 1st trimester	-0.017	-0.054, 0.021	-0.014	-0.051, 0.022	-0.014	-0.049, 0.022	0.017	-0.012, 0.046	0.018	-0.010, 0.046
2nd to end of 3rd trimester	-0.064	-0.094, -0.034	-0.035	-0.065, -0.005	-0.016	-0.057, 0.025	-0.029	-0.060, 0.002	-0.031	-0.060, -0.001
Small-for-gestational-age birth										
1-3 months prior to conception	0.031	-0.010, 0.072	0.032	-0.002, 0.066	0.010	-0.031, 0.051	-0.008	-0.052, 0.036	-0.006	-0.050, 0.038
Conception to 1st trimester	-0.029	-0.068, 0.011	-0.028	-0.067, 0.011	-0.029	-0.067, 0.010	0.000	-0.040, 0.041	-0.002	-0.040, 0.036
2nd to end of 3rd trimester	-0.056	-0.084, -0.029	-0.032	-0.058, -0.005	0.005	-0.031, 0.040	-0.015	-0.049, 0.019	-0.015	-0.048, 0.017

Abbreviations: B, beta coefficient; CI, confidence interval.

[a]All estimates are controlled for state and calendar month of conception fixed effects.

[b]Model 1 plus state-specific linear trends.

[c]Model 1 plus full set of interactions between state and year of conception fixed effects.

[d]Model 3 plus covariates (race, education, nativity, maternal age, live birth order, infant sex, plurality) after excluding observations with missing data on covariates.

[e]Model 4 plus covariates (race, education, nativity, maternal age, live birth order, infant sex, plurality) fully interacted.

Table 4. Effect of State Unemployment Around the Time of Conception and During Pregnancy on the Probability of PTB, LBW, and SGA.[a] National Center for Health Statistics Natality Files, All Registered Births to US Residents Conceived in the Period from January 1977 to March 2016. OLS Linear Probability Estimates, multiplied by 100, and Robust 95% Confidence Intervals.

	Births resulting from conceptions between January 1977 to March 2016							
	Full sample		Black women		Less educated		Black & less educated	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Preterm birth								
1-3 months prior to conception	-0.070	-0.110, -0.030	-0.181	-0.267, -0.094	-0.107	-0.167, -0.048	-0.222	-0.319, -0.124
Conception to 1st trimester	0.099	0.060, 0.138	0.193	0.117, 0.269	0.138	0.083, 0.194	0.273	0.150, 0.395
2nd to end of 3rd trimester	-0.053	-0.090, -0.016	-0.087	-0.167, -0.006	-0.066	-0.118, -0.013	-0.127	-0.250, -0.005
Low birth weight								
1-3 months prior to conception	0.019	-0.003, 0.040	-0.020	-0.074, 0.034	0.014	-0.021, 0.049	-0.023	-0.078, 0.031
Conception to 1st trimester	-0.014	-0.051, 0.022	-0.012	-0.105, 0.082	-0.009	-0.055, 0.036	-0.007	-0.122, 0.108
2nd to end of 3rd trimester	-0.035	-0.065, -0.005	-0.043	-0.103, 0.017	-0.040	-0.075, -0.005	-0.035	-0.110, 0.039
Small-for-gestational-age birth								
1-3 months prior to conception	0.032	-0.002, 0.066	0.023	-0.045, 0.090	0.006	-0.032, 0.044	0.024	-0.046, 0.095
Conception to 1st trimester	-0.028	-0.067, 0.011	-0.044	-0.126, 0.037	-0.013	-0.059, 0.033	-0.055	-0.157, 0.046
2nd to end of 3rd trimester	-0.032	-0.058, -0.005	-0.033	-0.092, 0.026	-0.050	-0.087, -0.013	-0.033	-0.102, 0.037
Observations	147,992,404		23,061,622		72,731,849		13,943,452	

	Births resulting from conceptions between January 2006 to March 2016							
	Full sample		Black women		Less educated		Black & less educated	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Preterm birth								
1-3 months prior to conception	-0.074	-0.122, -0.026	-0.125	-0.231, -0.018	-0.081	-0.193, 0.032	0.011	-0.164, 0.186
Conception to 1st trimester	0.185	0.090, 0.281	0.146	-0.015, 0.307	0.300	0.147, 0.454	0.349	0.012, 0.687
2nd to end of 3rd trimester	-0.092	-0.170, -0.014	-0.068	-0.197, 0.062	-0.189	-0.365, -0.013	-0.453	-0.759, -0.146
Low birth weight								
1-3 months prior to conception	-0.030	-0.061, 0.001	-0.068	-0.149, 0.014	-0.016	-0.072, 0.039	0.046	-0.111, 0.204
Conception to 1st trimester	0.060	0.014, 0.106	0.075	-0.045, 0.194	0.098	0.026, 0.171	0.168	-0.050, 0.387
2nd to end of 3rd trimester	-0.048	-0.084, -0.012	-0.063	-0.163, 0.038	-0.109	-0.188, -0.029	-0.247	-0.413, -0.081
Small-for-gestational-age birth								
1-3 months prior to conception	-0.009	-0.054, 0.037	-0.054	-0.174, 0.065	-0.043	-0.104, 0.019	-0.003	-0.134, 0.129
Conception to 1st trimester	-0.003	-0.062, 0.057	-0.004	-0.145, 0.137	0.026	-0.065, 0.116	-0.080	-0.256, 0.096
2nd to end of 3rd trimester	-0.032	-0.078, 0.015	-0.017	-0.100, 0.066	-0.051	-0.116, 0.013	0.025	-0.101, 0.151
Observations	41,209,568		6,579,977		16,155,297		3,141,243	

Abbreviations: B, beta coefficient; CI, confidence interval.

[a] All estimates are controlled for state and calendar month of conception fixed effects, and state-specific linear trends.

Supporting Information for “Economic Conditions and Inequities in Birth Outcomes: Evidence from 148 Million US Births”

CONDITIONING ON MONTH OF BIRTH VS. MONTH OF CONCEPTION

In the following, we outline how the omission of month of conception introduces omitted variable bias in the estimate of 1^{st} and $2^{nd}/3^{rd}$ trimester unemployment rates. Web Figure 1 shows a directed acyclic graph (DAG) encoding our theoretical model of causal associations between unemployment rates, month of conception, month of birth, and preterm birth. It is not a complete representation of the causal model, but focuses on the role month of conception and month of birth play as covariates in our analysis. Margerison-Zilko et al. (MZ) (1) condition on month of birth, but not on month of conception.

Month of birth is caused by month of conception, i.e., knowing the month of conception provides information about the likely month of birth. Month of conception in turn is caused by unobserved maternal factors (variable U in Figure 1) that also affect birth outcomes, including maternal socioeconomic status and intentionality of conception(2). The preterm birth rate in our data is highest for babies conceived in June (12.3%) and lowest for babies conceived in November (9.7%). Prior research has linked season of birth, which is in part determined by season of conception, as well as month of conception, to birth outcomes, long-term health outcomes, educational attainment and earnings (2,3). It is therefore not surprising that month of conception and month of birth become influential variables in our analysis.

Economic conditions become associated with maternal characteristics (U) through selective conceptions that are related to economic conditions, indicated by the dashed line between U and preconception unemployment rates. Previous research shows that economic conditions impact fertility rates and change the population composition of mothers who conceive (4,5).

Figure 1 illustrates that month of conception and pre-conception unemployment are important control variables when estimating the causal effects of unemployment during pregnancy. Both block non-causal, backdoor paths (via U) from unemployment during pregnancy to preterm birth that bias the estimated effect of first and second/third trimester unemployment on preterm birth. (Further strategies to address selection effects are described under "Robustness Checks" in our main manuscript.) However, because of elective and spontaneous terminations that could be related to economic conditions, it is again possible that unobserved factors confound the association between unemployment rates during pregnancy and preterm birth(1,6). This is visualized in the DAG with arrows from U into 1^{st} and $2^{nd}/3^{rd}$ trimester unemployment, which open up backdoor paths from 1^{st} and $2^{nd}/3^{rd}$ trimester unemployment to the outcome via U. These backdoor paths can be blocked by month of conception (and other covariates measuring mother's characteristics). However, they are not fully blocked by conditioning on month of birth, i.e., if month of conception is still associated with the outcome after month of birth is controlled.

Column 1 in Web Table 1 (Model 1) reports odds ratios from a logistic regression of preterm birth (=1) employing MZ's estimation strategy, including conditioning on state fixed effects, year of conception fixed effects, month of birth fixed effects, and the three unemployment rate variables included in our baseline model (equation 1, in our main manuscript). We use the same observation period as MZ (conceptions between 1990 and 2013), limit the sample to singleton births and also exclude observations with missing information on any of the covariates we have used in the analysis. Despite minor differences in sample definition and definition of covariates, our estimates are within rounding error of those reported by MZ (1, Table 2, Models 3-5).

The estimated odds ratio of first trimester unemployment is 1.04, while the OR for second/third trimester unemployment rates is 0.98. However, these estimates are confounded by omission of month of conception. Omitting month of conception leaves backdoor paths from, e.g., first trimester unemployment to preterm birth via U and month of conception, unblocked. This unblocked path contributes to the estimated association between first trimester unemployment and preterm birth.

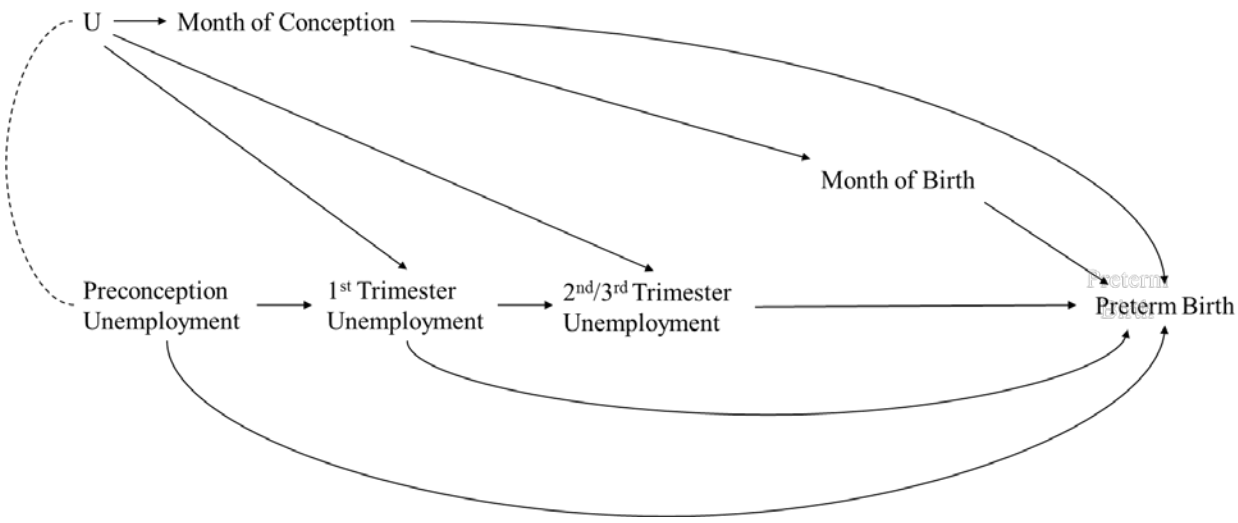
In column 2 (Model 2) we report estimates that are controlled for month of conception instead of month of birth, and in column 3 (Model 3) estimates controlled for month of conception and month of birth. Estimates in columns 2 and 3 are almost identical. Controlling for month of conception shrinks the estimate of both first and second/third trimester unemployment rate towards the null of 1, as we would expect. The first trimester effect, for example, shrinks from 1.04 to 1.01. Based on Figure 1, we argue that this is essentially due to blocking the non-causal backdoor path from unemployment to preterm birth via U and month of conception that caused omitted variable bias in the estimate that does not adjust for month of conception (column 1).

Model 3 results also show that we still observe sizeable effects of month of conception even with month of birth controlled, with odds ratios varying from 0.6 to 1.4. This is consistent with our causal model in Web Figure 1: conditioning on month of birth alone does not close all backdoor paths from unemployment during pregnancy to the outcome via U. A direct effect of month of conception on the outcome remains even after controlling for month of birth. This in turn supports our main argument that not controlling for month of conception leaves unblocked a backdoor path from unemployment during pregnancy to the outcome via U and month of conception, resulting in omitted variable bias in the unemployment estimates.

We repeated the analysis on the dataset used in our analysis reported in the main manuscript (all conceptions between January 1977 and March 2016). Model 1 and 2 in Web Table 2, illustrate effect sizes when conditioning on month of birth (Model 1) vs. month of conception (Model 2). Results are similar to those in Web Table 1. As a reference, Model 3 uses our baseline covariate specification without the covariates $\boldsymbol{X\gamma}$ (equation 1, main manuscript), identical to the Model 2 in Table 3 in the main manuscript.

Finally, we reran the models that produced the results reported in Web Table 2 using OLS regression. Results are reported in Web Table 3. For example, conditioning on month of birth, we observe that a one percentage point increase in unemployment rates during the first trimester increases the probability of preterm birth by 0.4 percentage points, which would be a sizeable effect. However, after conditioning for month of conception, the effect drops to around 0.1 percentage points, i.e., the effect of first trimester unemployment is only 25% of the estimate that does not adjust for month of conception. The reduction in effect sizes is of similar magnitude for the second/third trimester unemployment estimate.

Web Figure 1. Directed Acyclic Graph Illustrating Causal Pathways between Month of Conception, Month of Birth and Unemployment Rates Prior to and During Pregnancy.



Web Table 1. Adjusted Odds Ratios for Preterm Birth based on Multivariate Logistic Regression Models. All Singleton Births (n = 87,521,084), United States, 1990–2013.

	Model 1[a]		Model 2[b]		Model 3[c]	
	OR	CI	OR	CI	OR	CI
Average unemployment rate						
1-3 months prior to conception	0.976	0.966,0.986	0.993	0.986,1.000	0.991	0.984,0.998
Conception to 1st trimester	1.042	1.029,1.056	1.010	1.005,1.015	1.012	1.007,1.017
2nd to end of 3rd trimester	0.981	0.972,0.989	0.996	0.988,1.003	0.996	0.989,1.003
Month of Birth (Ref. January)						
February	0.961	0.954,0.968			0.939	0.919,0.960
March	0.958	0.946,0.970			1.423	1.326,1.527
April	0.952	0.940,0.963			1.422	1.301,1.554
May	0.997	0.984,1.011			1.897	1.678,2.145
June	1.020	1.005,1.035			1.711	1.471,1.991
July	0.988	0.976,1.001			1.383	1.187,1.613
August	0.926	0.911,0.942			0.958	0.825,1.112
September	0.841	0.825,0.857			0.726	0.636,0.828
October	0.952	0.925,0.980			1.087	0.958,1.233
November	0.932	0.917,0.947			0.872	0.814,0.934
December	0.977	0.970,0.983			1.092	1.057,1.129
Month of Conception (Ref. January)						
February			1.147	1.130,1.164	1.325	1.227,1.431
March			1.038	1.023,1.053	1.021	0.914,1.139
April			1.146	1.132,1.160	1.196	1.056,1.354
May			1.199	1.183,1.215	1.278	1.136,1.437
June			1.012	1.004,1.020	0.767	0.708,0.832
July			1.129	1.113,1.146	0.817	0.762,0.876
August			1.032	1.016,1.048	0.590	0.559,0.621
September			1.109	1.092,1.125	0.686	0.649,0.725
October			1.074	1.060,1.088	0.814	0.772,0.858
November			1.091	1.081,1.101	1.154	1.096,1.214
December			1.081	1.074,1.087	1.450	1.402,1.500

Abbreviations: OR, odds ratio; CI, 95% confidence interval.

[a]Estimates controlled for state fixed effects, year of conception fixed effects, and month of birth fixed effects.

[b]Estimates controlled for state fixed effects, year of conception fixed effects, and month of conception fixed effects.

[c]Estimates controlled for state fixed effects, year of conception fixed effects, month of birth fixed effects, and month of conception fixed effects.

Web Table 2. Adjusted Odds Ratios for Preterm Birth based on Multivariate Logistic Regression Models. All Births (n = 147,992,404), United States, 1977–2016.

	Model 1[a]		Model 2[b]		Model 3[c]	
	OR	CI	OR	CI	OR	CI
Average unemployment rate						
1-3 months prior to conception	0.975	0.968,0.982	0.992	0.986,0.997	0.994	0.990,0.998
Conception to 1st trimester	1.041	1.029,1.053	1.007	1.004,1.011	1.009	1.005,1.013
2nd to end of 3rd trimester	0.975	0.968,0.983	0.992	0.989,0.995	0.995	0.991,0.999

Abbreviations: OR, odds ratio; CI, 95% confidence interval.

[a]Estimates controlled for state fixed effects, year of conception fixed effects, and month of birth fixed effects.

[b]Estimates controlled for state fixed effects, year of conception fixed effects, and month of conception fixed effects.

[c]Estimates controlled for state fixed effects, calendar month of conception fixed effects, and state-specific linear trends.

Web Table 3. Beta Coefficients Multiplied by 100 for Preterm Birth based on Multivariate Ordinary Least Squares Regression Models. All Births (n = 147,992,404), United States, 1977–2016.

	Model 1[a]		Model 2[b]		Model 3[c]	
	Coef	CI	Coef	CI	Coef	CI
Average unemployment rate						
1-3 months prior to conception	-0.250	-0.314,-0.187	-0.092	-0.144,-0.041	-0.070	-0.110,-0.030
Conception to 1st trimester	0.400	0.294,0.507	0.084	0.049,0.119	0.099	0.060,0.138
2nd to end of 3rd trimester	-0.256	-0.323,-0.19	-0.088	-0.120,-0.056	-0.053	-0.090,-0.016

Abbreviations: Coef, coefficient; CI, 95% confidence interval.

[a]Estimates controlled for state fixed effects, year of conception fixed effects, and month of birth fixed effects.

[b]Estimates controlled for state fixed effects, year of conception fixed effects, and month of conception fixed effects.

[c]Estimates controlled for state fixed effects, calendar month of conception fixed effects, and state-specific linear trends.

Web Table 4. Effect of State Unemployment Around the Time of Conception and During Pregnancy on the Probability of PTB, LBW, and SGA.[a] National Center for Health Statistics Natality Files. OLS Linear Probability Estimates, multiplied by 100, and Robust 95% Confidence Intervals.

	Births resulting from conceptions between January 1977 to March 2016							
	Full sample		White women		More educated		White & more educated	
	Coef	CI	Coef	CI	Coef	CI	Coef	CI
Preterm birth								
1-3 months prior to conception	-0.070	-0.110,-0.030	-0.054	-0.097,-0.011	-0.032	-0.080,0.016	-0.033	-0.072,0.005
Conception to 1st trimester	0.099	0.060,0.138	0.089	0.040,0.137	0.092	0.041,0.143	0.089	0.032,0.145
2nd to end of 3rd trimester	-0.053	-0.090,-0.016	-0.045	-0.089,-0.001	-0.067	-0.113,-0.021	-0.065	-0.113,-0.017
Low birth weight								
1-3 months prior to conception	0.019	-0.003,0.040	0.003	-0.018,0.024	-0.003	-0.031,0.025	-0.018	-0.042,0.006
Conception to 1st trimester	-0.014	-0.051,0.022	0.017	-0.015,0.049	0.017	-0.014,0.048	0.031	-0.000,0.063
2nd to end of 3rd trimester	-0.035	-0.065,-0.005	-0.040	-0.061,-0.019	-0.040	-0.067,0.004	-0.029	-0.060,0.003
Small-for-gestational-age birth								
1-3 months prior to conception	0.032	-0.002,0.066	0.007	-0.030,0.044	0.001	-0.037,0.039	-0.008	-0.042,0.025
Conception to 1st trimester	-0.028	-0.067,0.011	0.008	-0.028,0.044	-0.005	-0.044,0.033	0.012	-0.023,0.048
2nd to end of 3rd trimester	-0.032	-0.058,-0.005	-0.037	-0.059,-0.016	-0.028	-0.059,0.003	-0.036	-0.061,-0.011
Observations	147,992,404		116,665,888		61,762,033		50,136,394	

	Births resulting from conceptions between January 2006 to March 2016							
	Full sample		White women		More educated		White & more educated	
	Coef	CI	Coef	CI	Coef	CI	Coef	CI
Preterm birth								
1-3 months prior to conception	-0.074	-0.122,-0.026	-0.073	-0.123,-0.024	-0.030	-0.107,0.047	-0.043	-0.109,0.024
Conception to 1st trimester	0.185	0.090,0.281	0.183	0.078,0.288	0.184	0.075,0.294	0.196	0.085,0.307
2nd to end of 3rd trimester	-0.092	-0.170,-0.014	-0.095	-0.173,-0.017	-0.145	-0.257,-0.034	-0.151	-0.265,-0.036
Low birth weight								
1-3 months prior to conception	-0.030	-0.061,0.001	-0.036	-0.069,-0.002	-0.016	-0.073,0.040	-0.033	-0.090,0.025
Conception to 1st trimester	0.060	0.014,0.106	0.066	0.025,0.107	0.053	-0.010,0.116	0.070	0.005,0.135
2nd to end of 3rd trimester	-0.048	-0.084,-0.012	-0.062	-0.094,-0.030	-0.059	-0.113,-0.005	-0.066	-0.123,-0.009
Small-for-gestational-age birth								
1-3 months prior to conception	-0.009	-0.054,0.037	-0.009	-0.050,0.032	-0.021	-0.075,0.033	-0.017	-0.069,0.034
Conception to 1st trimester	-0.003	-0.062,0.057	0.001	-0.045,0.047	-0.007	-0.071,0.056	-0.014	-0.071,0.043
2nd to end of 3rd trimester	-0.032	-0.078,0.015	-0.045	-0.091,0.002	-0.012	-0.059,0.036	-0.008	-0.060,0.043
Observations	41,209,568		31,448,181		20,791,120		16,185,382	

Abbreviations: Coef, coefficient; CI, 95% confidence interval.

[a] All estimates are controlled for state and calendar month of conception fixed effects, and state-specific linear trends.

REFERENCES

1. Margerison-Zilko CE, Li Y, Luo Z. Economic conditions during pregnancy and adverse birth outcomes among singleton live births in the united states, 1990-2013. *Am. J. Epidemiol.* 2017;186(10):1131–1139.
2. Buckles KS, Hungerman DM. Season of birth and later outcomes: old questions, new answers. *Rev. Econ. Stat.* 2013;95(3):711–724.
3. Mackay DF, Smith GCS, Cooper S-A, et al. Month of Conception and Learning Disabilities: A Record-Linkage Study of 801,592 Children. *Am. J. Epidemiol.* 2016;184(7):485–493.
4. Currie J, Schwandt H. Short- and long-term effects of unemployment on fertility. *Proc. Natl. Acad. Sci.* 2014;111(41):14734–14739.
5. Dehejia R, Lleras-Muney A. Booms, busts, and babies' health. *Q. J. Econ.* 2004;119(3):1091–1130.
6. Catalano R, Bruckner T, Anderson E, et al. Fetal death sex ratios: a test of the economic stress hypothesis. *Int. J. Epidemiol.* 2005;34(4):944–948.