Original Contribution

Economic Conditions During Pregnancy and Adverse Birth Outcomes Among Singleton Live Births in the United States, 1990–2013

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We know little about the relationship between the macroeconomy and birth outcomes, in part due to the methodological challenge of distinguishing effects of economic conditions on fetal health from effects of economic conditions on selection into live birth. We examined associations between state-level unemployment rates in the first 2 trimesters of pregnancy and adverse birth outcomes, using natality data on singleton live births in the United States during 1990–2013. We used fixed-effect logistic regression models and accounted for selection by adjusting for state-level unemployment before conception and maternal characteristics associated with both selection and birth outcomes. We also tested whether associations between macroeconomic conditions and birth outcomes differed during and after (compared with before) the Great Recession (2007–2009). Each 1-percentage-point increase in the first-trimester unemployment rate was associated with a 5% increase in odds of preterm birth, while second-trimester unemployment was associated with a 3% decrease in preterm birth odds. During the Great Recession, however, first-trimester unemployment was associated with a 16% increase in odds of preterm birth. These findings increase our understanding of the effects of the Great Recession on health and add to growing literature suggesting that macro-level social and economic factors contribute to perinatal health.

economy; Great Recession; low birth weight; preterm birth; small for gestational age; unemployment rate

Abbreviations: LBW, low birth weight; OR, odds ratio; PTB, preterm birth; SGA, small for gestational age.

Despite substantial research documenting associations between macroeconomic change and adult health (1–4), we know little about the relationship between the macroeconomy and birth outcomes such as preterm birth (PTB), low birth weight (LBW), and being born small for gestational age (SGA)—outcomes associated with infant morbidity and mortality as well as longer-term health (5, 6). A critical gap in our understanding of the causal relationship between the economy and birth outcomes lies in distinguishing the effects of economic conditions on fetal health from the effects of economic conditions on who is born (i.e., selection).

Macroeconomic change during pregnancy may affect maternal behaviors or psychosocial stress levels, which may have an impact on the child's birth weight and/or length of gestation (7). Indeed, 2 studies using US data from the 1980s and 1990s found that state-level economic downturn during pregnancy was associated with lower birth weight (8, 9). Announcements of job loss are also associated with increased risk of LBW (10) and declines in total birth weight attributable to shortened gesta-

tion (11), suggesting that stress regarding the economy may influence birth outcomes, even prior to actual job loss. Economic conditions in early pregnancy (i.e., the first trimester only (8) or the first and second trimester (9, 10)) are most strongly linked with birth outcomes, although one study found late pregnancy to be most salient (11). None of these studies, however, explicitly accounted for the potentially opposing forces of selection.

Specifically, economic conditions prior to conception may affect women's ability or choice to conceive, and economic conditions during pregnancy may affect the probability of spontaneous pregnancy loss or elective abortion. If selection results in fewer conceptions or live births among higher-risk women/pregnancies, adverse birth outcomes may appear to decline during or following economic downturns, offsetting or overpowering any detrimental effects of economic downturn on fetal health.

Indeed, evidence demonstrates declines in fertility during economic downturns, particularly among women under 30

years of age, who can postpone childbearing (12–14), and black teens (15, 16), who are at high risk of adverse pregnancy outcomes. In addition, a seminal study of US infants born between 1975 and 1999 suggests that declining fertility among black women with low education during economic downturns led to decreased rates of LBW and reduced neonatal and infant mortality (17). This study, however, examined unemployment rates in the year prior to conception, limiting its ability to distinguish between selection and effects of economic conditions on the health of pregnancies that did result in live births. A substantial body of research also suggests that economic downturns during mid-pregnancy induce pregnancy loss (18–20), particularly among smaller male fetuses. This phenomenon, termed selection in utero, may represent an adaptive mechanism to conserve maternal resources for later reproduction during less stressful times (20).

A lack of state- and time-specific data—particularly in the United States—on factors such as conception rates, spontaneous pregnancy loss (especially in early pregnancy), and elective abortion makes it difficult, if not impossible, to explicitly measure and control for selection when analyzing the relationship between economic conditions and birth outcomes. Thus, our first objective was to examine associations between state-level economic conditions (i.e., the unemployment rate) during pregnancy and adverse birth outcomes in the United States from 1990–2013, using multiple methods to account for selection effects in the absence of direct measures of selection. We hypothesized that, after accounting for a substantial portion of selection, exposure to economic downturn during the first and second trimesters of pregnancy would be associated with higher rates of adverse birth outcomes. We further hypothesized that first-trimester exposure to economic change would be most strongly associated with birth outcomes due to the importance of early physiologic processes, such as implantation and placental

development, for the growth and development of the fetus (21) and because prior work suggests that the maternal stress response becomes blunted as pregnancy progresses (22).

In addition, the recent Great Recession (2007–2009)—the most devastating economic crisis in the United States since the 1930s—may have had a unique impact on the relationship between economic conditions during pregnancy and birth outcomes. For example, increases in unemployment during this time may have had an impact on a wider range of individuals than would have been affected by increasing unemployment prior to the Great Recession. On the other hand, individuals may have come to expect job loss and rising unemployment as the Great Recession wore on, making such events less stressful at a population level. To our knowledge, no research has examined these hypotheses. Thus, our second objective was to examine differences in the relationship between state-level economic conditions and birth outcomes comparing the periods before, during, and after the Great Recession.

METHODS

Data and study population

We obtained individual-level birth data from the National Center for Health Statistics all-county natality files (National Center for Health Statistics, natality files for 1989–2013, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program), which include data on all live births in the United States from 1990–2013 ($n = 97,235,835$), including maternal state of residence.

Our analytical population included singleton births to US-resident women ages 15–44 years in the 50 US states or Washington, DC ($n = 93,828,927$) (Figure 1). We excluded

Figure 1. Flow chart for selection of the analytical sample of singleton births, United States, 1990–2013.

records missing length of gestation or birth weight, those with implausible combinations of birth weight and gestational age (23) ($n = 2,028,857$), and records missing maternal age, nativity, parity, or education ($n = 4,376,336$), resulting in a sample of 87,423,734 births.

We estimated months of pregnancy for each birth based on birth month and length of gestation. We then linked monthly, state-level unemployment data from 1988–2013, obtained from the Bureau of Labor Statistics *Local Area Unemployment Statistics* (24) to individual birth records by state and month of pregnancy. This linkage enabled us to assess exposure to state-level economic conditions by trimester of pregnancy. For example, for a pregnancy in Alabama that began in January 2000, the average first-trimester unemployment rate was based on the Alabama unemployment rate from January–March 2000, whereas the first-trimester average for a pregnancy starting in February 2000 was based on the unemployment rate from February through April 2000. Our analyses focused on economic conditions in the first and second trimesters of pregnancy because gestations lasting <9 months are missing data for the last trimester, and missing data would therefore be completely informed by the outcome in some analyses.

Measures

Unemployment rate. We calculated average unemployment rates (i.e., number of individuals seeking employment divided by total number in the workforce) over each of the first and second trimesters of pregnancy. Unemployment rates are a commonly used measure of economic conditions, are often reported in the media, and may thus measure the population's perception of the economy and facilitate comparison of findings with previous research. We also calculated a binary "high unemployment" variable, defined as values >8.8% unemployment (i.e., the 90th percentile of trimester-specific average unemployment). We defined the unemployment rate before conception as the average unemployment rate in the 6 months prior to conception. (Alternate specifications of 3 months and 12 months did not alter our findings.)

Great Recession. In the United States, the official dates of the Great Recession were December 2007 to June 2009 (25). We classified births as either before the Great Recession (born prior to December 2007), exposed to the Great Recession (born between December 2007 and March 2010—the last month of birth for which some portion of gestation could have been exposed to the official Great Recession), or after the Great Recession (born after March 2010).

Adverse birth outcomes. We examined 3 key adverse birth outcomes: 1) PTB, defined as <37 weeks, completed gestation; 2) LBW, defined as birth weight <2,500 grams; and 3) SGA, defined as <10th percentile of birth weight for gestational age using a published national reference (26). Although LBW is difficult to interpret—because it can be affected by length of gestation, fetal growth, or both—we included this measure to facilitate comparison with prior work. We used the natality data's "best estimate" of gestational age, which combines data based on last menstrual period and obstetric/clinical estimate (27).

Maternal characteristics. Maternal characteristics included: age (in years: <20, 20–29, 30–39, >40), race/ethnicity (American

Indian/Alaska Native, Asian/Pacific Islander, Hispanic, non-Hispanic black, non-Hispanic white, and other), nativity (US-born, foreign-born), parity (nulliparous, primiparous, multiparous), marital status (married, not married), and educational attainment. We used previously published methods to reconcile differences between the 1989 and 2003 version of the birth certificate in educational attainment (28), resulting in the following 5 categories: no high school/<9 years, some high school/9–11 years, high-school diploma/12 years, some college/13–15 years, college degree/≥16 years.

Statistical analysis

We calculated descriptive statistics (means and frequencies of all key variables) overall as well as within the periods before, during, and after the Great Recession. We estimated fixed-effects logistic regressions of our outcomes (PTB, LBW, and SGA) on the primary exposure variables—first- and second-trimester unemployment rates—using both the continuous and binary specifications. Model 1 included no additional covariates. Model 2 included fixed effects for month of birth (to control for seasonality), year of birth (to control for general secular trends associated with both birth outcomes and the economy), and state of birth (to account for time-invariant state characteristics associated with both birth outcomes and the economy). Model 3 included a control for the average unemployment rate in the 6 months prior to conception, which we hypothesized might influence selection into pregnancy. In model 4, we further controlled for observed maternal characteristics that may be related to both selection and birth outcomes: maternal age, race/ethnicity, nativity, marital status, parity, and education. We also controlled for infant sex, because prior research suggests that male gestations are more likely to face selection in utero during stressful economic times (20).

Model 5 added Great Recession–period variables; in model 6, we added an interaction term between first- and second-trimester unemployment and the Great Recession variables to determine whether the association between unemployment and birth outcomes differed by time period. Because prior research indicates that associations between the economy and infant health differ by maternal race/ethnicity and socioeconomic status (8, 10), we tested interactions between first- and second-trimester unemployment and maternal race/ethnicity, age, nativity, marital status, and educational attainment.

We assessed alternative model specifications, using a 1% sample of the entire data set to limit computing time, and compared these with a replication of the main analyses in the 1% sample. These included: generalized estimating equations using both independent and exchangeable correlation structures by state instead of state fixed effects; models with an indicator variable for the version of the birth certificate used (1989 vs. 2003) to account for differences in measurement and reporting of certain variables between versions; models excluding the unemployment-before-conception variable; and models excluding births with gestation length <6 months (which would have a shorter second trimester for exposure). We tested different specifications of our outcomes, including PTB using only the obstetric estimate, early PTB (<34 weeks gestation), very LBW (<1,500 g), and SGA among term infants only.

Such large sample sizes can result in statistical significance for small differences, and these data represent essentially the universe of births in our study sample; we therefore interpreted findings by placing greater weight on practical significance and magnitude of estimates rather than statistical significance. All analyses were completed using SAS, version 9.4 (SAS Institute, Inc., Cary, North Carolina).

RESULTS

Table 1 provides descriptive statistics on the 87,423,734 births in our analytical sample. Almost 60% of births were to non-Hispanic white women, 15% were to non-Hispanic black women, and almost 21% were to Hispanic women; 20.4% of births were to women born outside the United States. Almost 10% of births were preterm, 6.1% were LBW, and 10.3% were SGA.

Characteristics of births differed by Great Recession period on race/ethnicity, nativity, marital status, and educational attainment, supporting the need to control for these variables. Births to non-Hispanic white mothers declined in recent years, while births to Hispanic and Asian/Pacific Islander mothers increased, reflecting demographic trends. Proportions of Hispanic and foreign-born births declined slightly in post-Recession years, possibly reflecting the ebbing tide of immigration (29). Although a higher proportion of infants were born preterm during the Great Recession (10.2%) than after it (9.5%), PTB exhibits strong temporal trends (30, 31), underscoring the need for year fixed effects.

Table 2 provides results from fixed-effect regression models for PTB only, using the continuous unemployment-rate specification. Prior to adding state, year, and month fixed effects, unemployment was not associated with PTB. After adding fixed effects, each 1% increase in first-trimester unemployment was associated with 4% higher odds of PTB, and each 1% increase in second-trimester unemployment was associated with 3% lower odds of PTB. After including unemployment before conception (model 3), first-trimester unemployment was associated with 5% higher odds of PTB. Additional adjustment for maternal characteristics (model 4) did not substantially alter this estimate.

There was an interaction between the Great Recession and the unemployment rate (model 6). Prior to the Recession, each 1% increase in unemployment was associated with 2% higher odds of PTB; during the Recession, however, this increased to 16% higher odds, falling again to 4% in the post-Recession period. Second-trimester unemployment was associated with a larger reduction in odds of PTB after the Great Recession (odds ratio (OR) = 0.91), compared with during the Recession (OR = 0.94) and before it (OR = 0.97). Findings were substantively similar when using the binary high-unemployment specification (Web Table 1, available at <https://academic.oup.com/aje>). Although Wald tests for interactions between unemployment and maternal race/ethnicity, nativity, marital status, and education were significant, at $P < 0.05$, the point estimates for each trimester in each race or socio-demographic category were within 0.10 of each other and of the overall estimate reported for model 4, and confidence intervals for each category overlapped, leading us to

conclude that these interactions were not of substantive significance.

Unemployment during pregnancy was not associated with SGA, and associations between first- and second-trimester unemployment and LBW were similar in direction and magnitude to associations for PTB (Web Table 2). Alternative model specifications resulted in almost identical findings (Web Table 3). Associations between first-trimester unemployment and early PTB and very LBW were larger than those for PTB and LBW, and using alternative definitions of PTB and SGA did not substantively alter findings (Web Table 4).

The unexpected protective association between second-trimester unemployment and PTB suggested we may not have adequately accounted for selection in utero, which theory and evidence suggest acts primarily against weaker male gestations and could result in lower rates of male PTB (20). We thus conducted post-hoc sex-specific analyses to better understand this finding. We reported these findings to 3 decimal places based on the small, but potentially informative, associations. A test of the interaction between unemployment and infant sex demonstrated a slightly larger reduction in PTB among male infants (OR = 0.971) than among female infants (OR = 0.975), associated with a 1-unit increase in second-trimester unemployment, although confidence intervals on these estimates overlapped. This pattern persisted despite Great Recession period (Web Table 5). First-trimester unemployment was also associated with slightly higher odds of a birth being male (model 4, OR = 1.003), while second-trimester unemployment was associated with slightly lower odds (model 4, OR = 0.998) (Web Table 6). The lower odds of male births associated with second-trimester unemployment were observed prior to the Great Recession (OR = 0.998) and afterward (OR = 0.996) but not during (OR = 1.000) (Web Table 6).

DISCUSSION

We examined the relationship between state-level unemployment rates in the first- and second-trimester of pregnancy and adverse birth outcomes using data on US singleton births during 1990 to 2013. Our findings indicated that each 1-percentage-point increase in the unemployment rate in the first trimester was associated with 5% higher odds of PTB, whereas each percentage-point increase in the second trimester was associated with 3% lower odds of PTB. Findings were amplified during the Great Recession (2007–2009), when first-trimester unemployment was associated with 16% higher odds of PTB. Second-trimester unemployment was associated with 6% and 9% lower odds of PTB in Recession and post-Recession periods, respectively. Most states experienced increases in unemployment rates of 2 to 8 percentage points during the Great Recession, suggesting a substantial influence of state-level unemployment on PTB during this time.

Our data did not indicate any association between unemployment rates and SGA, and estimates for LBW were similar to those for PTB; associations between unemployment and LBW may therefore be driven by gestation length rather than reduced fetal growth. We did not find substantive differences in the relationship between unemployment and PTB by maternal race/ethnicity or sociodemographics.

Table 1. Descriptive Statistics for Singleton Births, Overall and According to Period Relative to the Great Recession ($n = 87,423,734$), United States, 1990–2013

Characteristic	Full Data Set		Before the Recession (Born Prior to December 2007)		Great Recession (Born Between December 2007 and March 2010)		After the Recession (Born After March 2010)	
	No. of Births	%	No. of Births	%	No. of Births	%	No. of Births	%
Sample size	87,423,734		65,911,750	75.4	8,966,366	10.3	12,545,618	14.4
Maternal characteristics								
Race/ethnicity								
Non-Hispanic white	51,990,640	59.5	40,287,399	61.1	4,847,915	54.1	6,855,326	54.6
Non-Hispanic black	13,079,716	15.0	9,958,681	15.1	1,306,244	14.6	1,814,791	14.5
Hispanic	18,215,557	20.8	13,025,888	19.8	2,199,323	24.5	2,990,346	23.8
American Indian/Alaska Native	838,335	1.0	631,358	1.0	92,863	1.0	114,114	0.9
Asian/Pacific Islander	3,299,486	3.8	2,008,424	3.1	520,021	5.8	771,041	6.2
Age, years								
<20	9,702,214	11.1	7,769,972	11.8	918,316	10.2	1,013,926	8.1
20–29	46,496,658	53.2	35,163,799	53.4	4,780,320	53.3	6,552,539	52.2
30–39	29,381,489	33.6	21,688,097	32.9	3,048,076	34.0	4,645,316	37.0
>40	1,843,373	2.1	1,289,882	2.0	219,654	2.5	333,837	2.7
Nativity								
US-born	69,584,242	79.6	53,107,107	80.6	6,796,634	75.8	9,680,501	77.2
Foreign-born	17,839,492	20.4	12,804,643	19.4	2,169,732	24.2	2,865,117	22.8
Parity								
Nulliparous (0 previous live births)	35,646,411	40.8	26,900,710	40.8	3,670,092	40.9	5,075,609	40.5
Primiparous (1 previous live birth)	28,145,431	32.2	21,360,137	32.4	2,821,516	31.5	3,963,778	31.6
Multiparous (>1 previous live birth)	23,631,892	27.0	17,650,903	26.8	2,474,758	27.6	3,506,231	28.0
Marital status								
Married	56,708,376	64.9	43,960,917	66.7	5,296,899	59.1	7,450,560	59.4
Not married	30,715,358	35.1	21,950,833	33.3	3,669,467	40.9	5,095,058	40.6
Educational level								
Less than high school	4,887,341	5.6	3,877,007	5.9	473,463	5.3	536,871	4.3
Some high school	13,714,591	15.7	10,723,123	16.3	1,347,135	15.0	1,644,333	13.1
High-school diploma	27,290,353	31.2	21,612,473	32.8	2,492,999	27.8	3,184,881	25.4
Some college	20,420,656	23.4	14,563,858	22.1	2,273,656	25.4	3,583,142	28.6
College graduate	13,428,228	15.4	9,608,989	14.6	1,513,185	16.9	2,306,054	18.4
Greater than college	7,682,565	8.8	5,526,300	8.4	865,928	9.7	1,290,337	10.3
Infant sex								
Male	44,753,944	51.1	33,741,454	51.2	4,588,279	51.1	6,424,211	51.2
Female	42,669,790	48.8	32,170,296	48.8	4,378,087	48.8	6,121,407	48.8
Outcomes								
Low birth weight	5,291,214	6.1	3,952,592	6.0	563,100	6.3	775,522	6.2
Preterm birth	8,614,826	9.9	6,508,509	9.9	911,443	10.2	1,194,874	9.5
Small for gestational age	8,016,443	10.3	5,903,502	10.1	869,356	10.8	1,243,585	10.9
Exposures								
First-trimester unemployment rate ^a	6.1 (2.0)		5.5 (1.4)		6.2 (2.1)		8.9 (1.9)	
Second-trimester unemployment rate ^a	6.1 (2.0)		5.5 (1.4)		6.7 (2.3)		8.8 (1.9)	

^a Values are expressed as mean (standard deviation).

Table 2. Unadjusted and Adjusted Odds Ratios for Preterm Birth From Logistic Regression Models for Singleton Births ($n = 87,423,734$), United States, 1990–2013

Variable	Model 1		Model 2 ^a		Model 3 ^a		Model 4 ^a		Model 5 ^a		Model 6 ^a	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Unemployment rate												
First trimester	1.00	0.99, 1.00	1.04	1.04, 1.05	1.05	1.05, 1.05	1.05	1.05, 1.05	1.05	1.05, 1.05		
Second trimester	1.00	1.00, 1.00	0.97	0.97, 0.98	0.97	0.97, 0.98	0.97	0.97, 0.97	0.97	0.97, 0.97		
Unemployment before conception					0.99	0.99, 0.99	0.99	0.99, 0.99	0.99	0.99, 0.99	1.02	1.02, 1.02
Infant sex												
Male							1.00	Referent	1.00	Referent	1.00	Referent
Female							0.89	0.89, 0.89	0.89	0.89, 0.89	0.89	0.89, 0.89
Maternal age, years												
<20							1.04	1.04, 1.04	1.04	1.04, 1.04	1.04	1.04, 1.04
20–29							1.00	Referent	1.00	Referent	1.00	Referent
30–39							1.18	1.17, 1.18	1.18	1.17, 1.18	1.18	1.17, 1.18
>40							1.61	1.60, 1.61	1.61	1.60, 1.61	1.61	1.60, 1.61
Maternal race/ethnicity												
Non-Hispanic white							1.00	Referent	1.00	Referent	1.00	Referent
Non-Hispanic black							1.69	1.68, 1.69	1.69	1.68, 1.69	1.69	1.68, 1.69
Hispanic							1.18	1.18, 1.18	1.18	1.18, 1.18	1.18	1.18, 1.18
American Indian/Alaska Native							1.19	1.19, 1.20	1.19	1.19, 1.20	1.19	1.18, 1.20
Asian/Pacific Islander							1.29	1.29, 1.30	1.29	1.29, 1.30	1.29	1.29, 1.30
Maternal nativity												
US-born							1.00	Referent	1.00	Referent	1.00	Referent
Foreign-born							0.86	0.86, 0.87	0.86	0.86, 0.87	0.86	0.86, 0.87
Parity												
Nulliparous							1.00	Referent	1.00	Referent	1.00	Referent
Primiparous							0.91	0.91, 0.91	0.91	0.91, 0.91	0.91	0.91, 0.91
Multiparous							1.02	1.02, 1.03	1.02	1.02, 1.03	1.02	1.02, 1.03
Maternal marital status												
Married							1.00	Referent	1.00	Referent	1.00	Referent
Not married							1.25	1.25, 1.25	1.25	1.25, 1.25	1.25	1.25, 1.25
Maternal educational level												
Less than high school							1.50	1.49, 1.51	1.50	1.50, 1.51	1.50	1.49, 1.51
Some high school							1.53	1.53, 1.54	1.53	1.53, 1.54	1.53	1.53, 1.54
High-school diploma							1.34	1.34, 1.35	1.34	1.34, 1.35	1.34	1.34, 1.35
Some college							1.23	1.22, 1.23	1.23	1.22, 1.23	1.23	1.22, 1.23
College graduate							1.03	1.02, 1.03	1.03	1.02, 1.03	1.03	1.02, 1.03
Greater than college							1.00	Referent	1.00	Referent	1.00	Referent

Table continues

Table 2. Continued

Variable	Model 1		Model 2 ^a		Model 3 ^a		Model 4 ^a		Model 5 ^a		Model 6 ^a	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Great Recession (2007–2009) indicator												
Before the Recession									1.00	Referent		
During the Recession									1.00	0.99, 1.01		
After the Recession									0.99	0.98, 1.01		
Great Recession × unemployment rate												
Before the Recession											1.02	1.02, 1.02
First trimester											0.97	0.97, 0.98
Second trimester												
During the Recession												
First trimester											1.16	1.16, 1.17
Second trimester											0.94	0.94, 0.94
After the Recession											1.04	1.04, 1.05
First trimester											0.91	0.91, 0.92
Second trimester												

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

^a For models 2–6, fixed-effect variables for state, month, and year were included in the model.

Our finding that higher unemployment in early pregnancy was associated with higher odds of PTB is mostly consistent with results of prior studies reporting that economic downturns are associated with lower birth weight or SGA (8–10), although our data indicated associations between unemployment and PTB only, not SGA. On the other hand, our finding that increasing unemployment in mid-pregnancy was associated with reduced odds of PTB did not support our original hypothesis. This finding is consistent, however, with prior evidence that stressful economic times—particularly in mid-pregnancy—may induce selection in utero, leading to relatively better outcomes among gestations carried to term (18–20, 32). It remains possible, therefore, that our methods to account for selection did not control for mid-pregnancy selection in utero as adequately as they controlled for selective forces during the first trimester. Indeed, our post-hoc analyses provided some evidence of reduced odds of a male birth associated with second-trimester unemployment and indicated that the reduction in odds of PTB was strongest for male infants. Thus, some of the PTB decrease associated with second-trimester unemployment may be due to selection in utero. On the other hand, these sex-specific findings were small relative to the overall association, suggesting that increases in unemployment in the second trimester may act to reduce PTB via other mechanisms, such as by increasing health-promoting behaviors.

Our findings support an amplification of overall associations between state-level unemployment rates and PTB during the Great Recession. A Recession-period 1-unit increase in unemployment from, for example, 8% to 9% may affect a wider group of individuals or be more stressful at the population level than a pre-Recession 1-unit increase from, for example, 4% to 5%. Increases in the unemployment rate coupled with other sequelae of the Great Recession (e.g., collapse of the housing market) may also have amplified stress or behavioral responses affecting women's health.

To our knowledge, no prior study has examined associations between economic conditions and birth outcomes for the entire United States from 1990 through the Great Recession. Our analysis paid particular attention to potential selection against high-risk pregnancies during economic downturns and used 2 methods to account for some of this selection, although in the absence of direct measures of conception rates, spontaneous pregnancy loss, and elective abortion, we cannot control for all selection.

These data are not without limitations. It is nearly impossible to measure length of gestation with complete accuracy in naturally conceived pregnancies; outcomes are therefore subject to measurement error. We do not anticipate that measurement error depends on economic conditions, so any resulting bias in the odds ratio will be, in general, toward the null. Second, natality data do not include extensive individual- or household-level data on economic conditions (e.g., employment, income), limiting our ability to examine these variables as potential mechanisms. Future work should seek to identify specific pathways by which the macroeconomy influences birth outcomes to inform clinical practice or public policy. Notably, prior work implicates fear and psychosocial stress as playing an important role in the relationship between the economy and birth outcomes (10, 11). Moreover, recent research suggests that unemployment benefits are positively correlated with mental and self-rated health (33, 34); the

impact of such safety-net policies on pregnancy health should also be examined.

We chose to use unemployment rates because they: 1) were available for the entire study period, 2) facilitate comparison of findings with those of prior research, 3) typically increase during economic downturns, and 4) are frequently reported in the media. We chose to use state-level rates because county-level estimates are likely estimated with considerable error (35), and recent work shows that estimates of associations between economic conditions and health using counties may be less reliable than estimates based on state-level measures (36). However, the unemployment rate may not accurately reflect economic conditions when many workers are discouraged from seeking work, and state-level rates may not reflect local economic conditions, particularly in large, geographically or economically diverse states.

In conclusion, our study found that first-trimester increases in the unemployment rate were associated with higher odds of PTB but that second-trimester unemployment was associated with lower odds of PTB; these estimates were particularly strong during and after the Great Recession compared with beforehand. This study advances our understanding of how macro-level economic conditions influence birth outcomes and provide up-to-date evidence on the impacts of the recent Great Recession on adverse birth outcomes in the United States. In light of the fact that neither the high rates of PTB nor the race and socioeconomic disparities in PTB in the United States are fully explained by individual-level risk factors (37–39), this study provides important evidence supporting the argument that macro-level factors may at times play an important role in the health and outcomes of pregnancy.

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