



Article

The Great Recession and adverse birth outcomes: Evidence from California, USA

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ABSTRACT

Objectives: Prior studies of the health effects of recessions have shown mixed results. Ecological studies often report a positive relationship between economic downturns and population health while individual-level studies often show that conditions related to recessions are deleterious. Our study examines the spatially and temporally heterogeneous effects of the Great Recession (TGR) on adverse birth outcomes, a contemporaneous measure of population health that is highly responsive to changing social conditions.

Methods: We use restricted birth cohort data from California (2004–2012) merged with both county- and tract-level socio-demographic data, to explore birth selectivity and temporal and unemployment effects during TGR on adverse birth outcomes.

Results: We find that gestational exposure – more specifically, second trimester exposure – during or adjacent to the months of TGR was generally deleterious for birth outcomes, more so, in some cases, for mothers with lower levels of education, and that increases in county-level unemployment were generally deleterious for birth outcomes.

Conclusions: Although recessionary effects on population health are problematic and may have far-reaching effects, it appears that these effects may be largely universal, even given potential selective fertility favoring advantaged groups.

Introduction

The effects of the Great Recession (TGR) were particularly broad and had profound implications for employment, wealth, income, poverty, food insecurity, housing values, and the American financial system (Grusky, Western, and Wimer 2011). The health implications of TGR are now being realized, although the long-term health impact of TGR may not be known for decades. While TGR was coupled with a global recession and affected the nation as a whole, the impact of TGR was also demographically heterogeneous and geographically dispersed (Elsby, Hobijn, & Sahin, 2010). For example, increases in the unemployment rate, lengthier bouts of unemployment, and health insurance loss were more concentrated among those with lower socioeconomic status (Hoynes, Miller & Schaller, 2013; Holahan, 2010). Racial disparities were evident as well, as wealth declined by 16% in White households (2005–2009) and by 65% and 53% among Black and Hispanic households, respectively (Ellen and Dastrup 2012); home ownership rates also dropped the most in these two racial/ethnic minority groups (Ellen and

Dastrup 2012). Additionally, the effects of TGR varied widely across metropolitan areas (Kneebone & Garr, 2010); for instance, housing prices fell nearly 59% from their peak in Las Vegas but fell only 10% in Denver (Ellen and Dastrup 2012).

The primary aim of our study is to better understand the impact of these recessionary trends on adverse birth outcomes, a harbinger of decline in population health. Although studies of the effects of TGR on population health and health disparities have grown in the past few years (for recent reviews, see Burgard, Ailshire, & Kalousova, 2013; Margerison-Zilko, Goldman-Mellor, Falconi, & Downing, 2016, e.g.), less attention has been paid to disparities at birth and the mechanisms through which TGR may have adversely impacted birth outcomes. We also draw on numerous studies that have examined the consequences of prior recessions for population health, the results of which are mixed and widely debated. We extend TGR research by examining the heterogeneous effects of TGR, using a diverse set of local indicators, on birth outcomes, a contemporaneous measure of population health that is highly responsive to changing socioeconomic conditions and has

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profound, life-long implications for health and wellbeing.

Recessions and population health

There are two disciplinary streams of research that have detailed the health consequences of prior recessions. The first stream of research relies heavily on ecological data and contemporaneous measures of health and mortality (for a description, see Burgard et al., 2013). This research reports a pro-cyclical relationship between macroeconomic fluctuations and declines in population health; that is, that mortality slightly increases when the economy is growing and slightly decreases during recessions (e.g., Tapia Granados, 2005; Ruhm, 2000; Tapia; Strumpf, Charters, Harper, & Nandi, 2017). With respect to birth outcomes, literature on earlier recessionary periods found mixed evidence for a pro-cyclical pattern for infant mortality and low birthweight (Chay & Greenstone, 2003; Dehejia & Lleras-Muney, 2004; Ruhm, 2000, but see; Catalano & Serxner, 1992; Catalano, Hansen, & Hartig, 1999; Fisher, LoGerfo, & Daling, 1985; Gerdtham & Ruhm, 2006). However, research also suggested that such pro-cyclical associations may have waned in recent decades (Ensor, Cooper, Davidson, Fitzmaurice, & Graham, 2010). Research spanning the beginning of TGR (1999–2008), finds that advanced notice of a firm's layoffs is associated with an increase in rates of low birthweight in the respective county (Carlson, 2015). Whereas increased psychosocial stress, poorer nutrition, and a disruption of health services are likely mechanisms underlying this counter-cyclical pattern (Margerison Zilko, 2010), the proposed mechanisms implicated in a procyclical pattern include better environmental and workplace conditions (e.g. less traffic, pollution, fewer workplace accidents) as well as less disposable income to spend on deleterious health behaviors (e.g. eating out, smoking, alcohol) (Ruhm, 2000; Noland and Zhou 2017 but see Smith, Ng, & Popkin, 2014).

There is also a second stream of research on the health consequences of prior recessions that suggests that recessions may have counter-cyclical effects on adverse health outcomes. This literature largely relies on individual-level data to examine links between health and *events that are indicative of recession* (e.g. job loss, financial strain, and income reductions) and reports that people who are directly affected by economic downturn often suffer greater health risks (for a review, see Catalano et al., 2011) and unmet health care needs (Huang, Birkenmaier, & Kim, 2014). For example, studies show that employment is associated with lower mortality (Ross & Mirowsky, 1995) and that individuals experiencing a recent job loss have a much higher probability of developing future health problems (Strully, 2009)—although the long-term implications for mortality may not follow for decades (Sullivan & Von Wachter, 2009). Other studies show that job loss due to massive layoffs increased mortality 50–100% in the year following displacement for men (Sullivan & Von Wachter, 2009), and Dooley and Prause (2005) find that shifts to less than adequate employment were associated with lower birthweights; the local unemployment rate operated through mother's employment status with no independent impact on infant birthweight. Still other multi-level work directly examines the impact of aggregate-level economic conditions on individual health outcomes.

Recent work finds that state-level unemployment exposure in utero had a more profound impact on birth outcomes during TGR than during other periods (Margerison-Zilko, Li, & Luo, 2017; Noelke, Chen, Osypuk, & Acevedo-Garcia, 2019). Likewise, data from Iceland suggests increased odds of low birthweight during their economic collapse (Eiríksdóttir et al., 2013). Research across both streams of literature suggests that economic contractions may have indirect effects that are not accounted for by events such as unemployment (e.g. Burgard, Brand, & House, 2009; Carlson, 2015; Modrek & Cullen, 2013). For example, the simple perception of layoff threat has been shown to affect the average birthweight of infants born to women in geographies/employment sectors experiencing widespread layoffs (Catalano & Serxner, 1992). Perceptions of job insecurity are also found to predict up to twice the risk of

non-fatal heart attacks in women (Lee et al., 2004), and perceptions of housing or food insecurity are found to have similar health consequences (see review by Burgard et al., 2013).

Additionally, research has shown there to be variation across social and geographic spaces in the relationship between economic conditions and health. There is considerable heterogeneity, for example, in the impact of economic fluctuations by age, race-ethnicity, education level and gender (e.g. Dudel & Myrskylä, 2017; Riva, Bamba, Easton, & Curtis, 2011). Although the evidence is decidedly mixed, some studies suggest that disadvantaged groups may be more negatively impacted by economic downturn (e.g. Charles & DeCicca, 2008; Edwards, 2008; Margerison-Zilko, 2014; Margerison-Zilko et al. 2010; Martikainen & Valkonen, 1996; Noelke et al., 2019; Riva et al., 2011). For instance, Margerison-Zilko and colleagues (2010) find that economic contractions in the first trimester were associated with stronger decreases in birthweight for gestational age for women with less than twelve years of education, but found no differences by race/ethnicity. Using national birth certificate data from 1977 to 2016, Noelke et al. (2019) find that preterm births among the least educated black women are the most adversely impacted by economic downturns measured by unemployment at the state-level. Other work, finds that educational inequality in low birthweight and pre-term birth is exacerbated during TGR in Spain (Juárez, Revuelta-Eugercios, Ramiro-Fariñas, & Viciano-Fernández, 2014). In terms of employment, research finds that economic downturns had more pronounced negative consequences for low birthweight among non-employed women during Iceland's economic collapse (Eiríksdóttir et al., 2013), and for small for gestation age among women "keeping house" in the U.S. prior to TGR (Margerison-Zilko et al. 2010), although health selection is a serious methodological challenge to understanding heterogeneous employment effects (Burgard, Brand, & House, 2007).

In terms of geographic variation, much of the work examining the impacts of recessions on health measures explore macro-economic conditions at the country- (e.g. Gerdtham & Ruhm, 2006) or state-level (e.g. Margerison-Zilko et al. 2010; Margerison-Zilko et al., 2017). Yet, past studies indicate that the consequences of macro-economic decline may be heterogeneous at a finer level of geography (e.g. Charles & DeCicca, 2008; Currie & Tekin, 2011; Modrek et al. 2013). For instance, a recent analysis of the effects of foreclosure activity and health using data from states that were among the hardest hit by the foreclosure crisis found that zip codes with the most foreclosures saw the largest increase in the incidence of emergency room visits, including the largest estimated effects on heart attack and stroke among blacks (Currie & Tekin, 2011). One recent study, using longitudinal data from Michigan finds evidence that increases in county-level unemployment are associated with increases in preterm births between 1990 and 2012 with more pronounced relationships during TGR, specifically (Margerison, Luo, and Li 2019).

Finally, there is some concern that the link between infant health and mortality and economic conditions is, instead, a function of selective fertility (Yu & Sun, 2018). Evidence from the early years of the recession (2008–2009), as well as a longer time-span shows evidence of a reduction of fertility during this time period (e.g. Cherlin, Cumberworth, Morgan, & Wimer, 2013; Goldstein, Kreyenfeld, Jasilioniene, & Örsal, 2013; Schneider, 2015). Early national-level work in the US found that the recession was associated with greater fertility declines among the poor and near poor; other work found reductions in fertility for the countries most impacted by TGR (Goldstein et al., 2013). Schneider (2015), capturing the recession across a longer time span, at multiple levels of geographic aggregation, and with a variety of operationalizations, likewise finds that fertility declined the most in areas hardest hit by foreclosure and unemployment in the U.S. Beyond conscious delays, there is evidence from Denmark that suggests that fertility declines may also be a function of spontaneous abortions in response to poor economic conditions (Bruckner, Mortensen, & Catalano, 2016). If women are delaying their births or unable to carry to term in response to poor

economic conditions, we may expect that the remaining births may be comprised of a heterogeneous group of families, including those most able to financially weather TGR, older women who can no longer delay their fertility, those with strong pro-natalist values, or those most unable to prevent unintended births.

Birth outcomes as contemporaneous indicators of population health

It is well established that the interuterine period is highly responsive to environmental change and critical for later health outcomes, with insults in the first trimester often being deleterious for both birth outcomes and future health (Almond and Currie 2011; Barker 1995; Margerison_Zilko et al., 2010; Noelke et al., 2019). The impact of economic insults on birth outcomes may also extend into later trimesters (Catalano, Zilko, Saxton, & Bruckner, 2010; Noelke et al., 2019). There are also a number of individual-level pathways through which recessions might impact birth outcomes, including loss of resources, increased stress, diminished nutrition and personal care, and negative coping behaviors (Margerison Zilko, 2010). For instance, Margerison-Zilko (2014) finds that worse than expected state-level unemployment is associated with increased alcohol consumption during the first and second trimester among Non-Hispanic Black women.

Beyond the theoretical and empirical value of using birth outcomes to measure population health, the consequences of recessions for birth outcomes are especially important to examine given the life-course implications of poor infant health (Hayward and Gorman 2004). Low birth-weight is the leading cause of infant mortality (Hummer, 1993) and low birth-weight children are more likely to experience a host of negative outcomes in childhood, including: reduced cognitive ability and more behavioral problems, higher school drop-out rates, and more health problems (Conley & Bennett, 2000; Corman & Chaikind, 1993; Currie & Hyson, 1999). In addition, the effects of birthweight and compromised birth outcomes extend well into adulthood with low-birth-weight individuals having lower socio-economic status (Currie & Hyson, 1999) and higher rates of morbidity (Barker, 1995; Hack et al., 2002; Rich-Edwards et al., 2005) and mortality (Risnes et al., 2011). Further, birth outcome disparities mirror larger social inequalities (Gortmaker & Wise, 1997; Hummer 1993; Kleinman & Kessel, 1987, but see; Finch, Lim, Perez, & Do, 2007; Markides & Coreil, 1986). Finally, adverse birth outcomes are affected by the broader socio-economic environment. For example, low birth-weight has been associated with several community-level factors, including: poverty (Roberts, 1997), unemployment (Pearl, Bravemen, and Abrams 2001), income (O'Campo Xue, and Wang 1997), and crime (Morenoff, 2003). A handful of studies have demonstrated that neighborhood poverty, segregation, residential instability, and violent crime are all linked to lower infant birthweights and a greater risk for being born low birth-weight (Buka, Brennan, Rich-Edwards, Raudenbush, & Earls, 2003; Roberts, 1997; O'Campo, Xue, Wang, & O'Brien Caughy, 1997; Pearl, Bravemen).

Economic downturns and adverse birth outcomes

Overall, research suggests that adverse birth outcomes mirror social inequality (Gortmaker and Wise, 1997) and are highly responsive to dynamic social conditions in both the local neighborhood environment and the broader political economy. The effects of adverse birth outcomes extend from childhood to adulthood and will have long-term impacts on population health (Hayward and Gorman 2004). The socially marginalized are also known to bear the brunt of compromised birth outcomes and this is reflected in the disparities in birthweight and length of gestation that persist across socio-economic and racial/ethnic groups (Burriss & Hacker, 2017). While several studies have shown that birth outcomes are affected by the broader socio-economic environment, thus far only a handful of studies reviewed above show that catastrophic economic events such as TGR may have deleterious effects on birth

outcomes. Further, the few studies to identify whether such associations differ by trimester(s) of exposure mostly rely exclusively on state-level measures of unemployment. Alongside Margerison and colleagues (2019) study of Michigan, our study will contribute to this gap by examining the effects of TGR using more local, county-level measures of unemployment in one of the largest states in the country. We also examine whether the effects of gestational exposure to TGR persisted across trimesters, above and beyond the effects of unemployment. Lastly, although poor economic conditions may yield small mortality benefits for some, they may also greatly harm the health of more disadvantaged populations (Charles & DeCicca, 2008; Edwards, 2008). The large spatial and temporal variation in one of the largest recessions in American history suggests that both of these trends need to be explored, in addition to their heterogeneous effects on population sub-groups.

Research questions

Having demonstrated the empirical and theoretical value of examining birth outcomes as a measure of population health, we aim to address gaps in the literature on the health consequences of recessions, by 1) assessing how gestational exposure to TGR is associated with birth outcomes, using a diverse set of local GR indicators as well as a richer set of individual-level, pregnancy behavior indicators unavailable in national vital statistics data, and 2) measuring the differential impact TGR may have had on birth outcomes across educational and racial/ethnic sub-groups. Our overarching hypothesis is that gestational exposure to TGR adversely affected birth outcomes, especially among disadvantaged groups. To explore this hypothesis, we focus on low birth-weight and preterm birth as our adverse birth outcomes, and propose the following research questions:

1. Do births decline during the time period of TGR? (Q1)
2. Does gestational exposure to TGR have deleterious effects on birth outcomes?
 - a. Are increased unemployment rates during the first and second trimester negatively associated with adverse birth outcomes? (Q2a)
 - b. Is temporal proximity of the first or second trimester to TGR associated with adverse birth outcomes? (Q2b)
 - c. Do the effects of TGR diminish when adjustments are made for behaviors during pregnancy (e.g. adequacy of care, health behaviors during pregnancy, and utilization of nutrition resources)? (Q2c)
3. Are associations between gestational exposure to TGR and adverse birth outcomes more concentrated in disadvantaged groups? (Q3)

Data and methods

Data sources

We use two data sets to answer our research questions. First, we created the California recession database (CARD) that varies both spatially (counties) and temporally (monthly) using several data sources described as follows. We obtained labor market outcome data from the Bureau of Labor Statistics which reports a monthly time series of unemployment data by county from 1999 to 2013. We then obtained data from Zillow which reports monthly data on housing values at the county level. We collected data on the number of people enrolled in General Relief and CalWorks programs by CA county, using reports from the California Department of Social Services website, as a control for social safety nets. Finally, we obtained census-tract level measures of neighborhood disadvantage using data from the 2000 and 2010 U.S. Census as a control for contextual demographic characteristics of one's local residence—often referred to as neighborhood socio-economic context.

Second, the core individual-level data come from the Birth Cohort File available via restricted data agreement from the California Department of Public Health. These data contain all live births in

California for every calendar year from 2004 and 2012, and include all information available on a standard birth certificate form, including: detailed race/ethnicity of the mother/father, age of the mother, mother's birthdate, total births, birth order, date of birth/delivery, date of last live birth, date of last menses, nativity of the mother/father (birthplace), gender of the child, birth-weight of the child, gestational age of the child, prenatal care and month prenatal care began, primary payer for delivery (health insurance status), maternal/paternal education, labor complications, delivery complications, smoking status and the exact address of the mother's residence. For our descriptive Fig. 1, we adjust birth counts using annual California population data from the American Community data (U.S. Census Bureau, 2005–2012).

Although vital statistics data are not error-free and medical records remain the gold standard for reporting of birthweight (Lantz and Partin 1994), several validation studies show that birth certificate data are highly accurate in reflecting birthweight and concordance between medical records and birth certificates ranges from 87 to 100% (Buescher et al., 1993; NCHS 1985; Piper et al., 1993; Querec 1980). As such, we focus primarily on low-birthweight as an important indicator of adverse birth outcomes. On the other hand, while the gold standard for estimating gestation length remains using last menstrual period and date of

birth, these data are much less reliable (Behrman and Stith Butler 2007). We do estimate recessionary effects on preterm birth, however, noting that there may be more measurement error in this dependent variable, which would be absorbed in the error term and not bias recessionary effects. At the same time, our goal is not estimating the prevalence of these outcomes, and as long as poor recall is not correlated with variations in the recession, then our results should remain unbiased. That is, overall error in reporting date of last menses may bias intercepts, but should not bias beta estimates.

Measures and methods

To measure gestational exposure to TGR, we draw on the following two indicators, measured during the first and second trimesters of gestation: 1) temporal proximity to TGR, two series of dummy variables, one for each of the two trimesters, identify whether the first and second trimesters occurred during any months of TGR or during the 12 months before or after TGR (not proximal to TGR, during TGR, year before TGR, year after TGR), and 2) a continuous, county-level measure of the average unemployment rate during the first and second trimesters.

First trimester is operationalized as days 1 through 97 of gestation

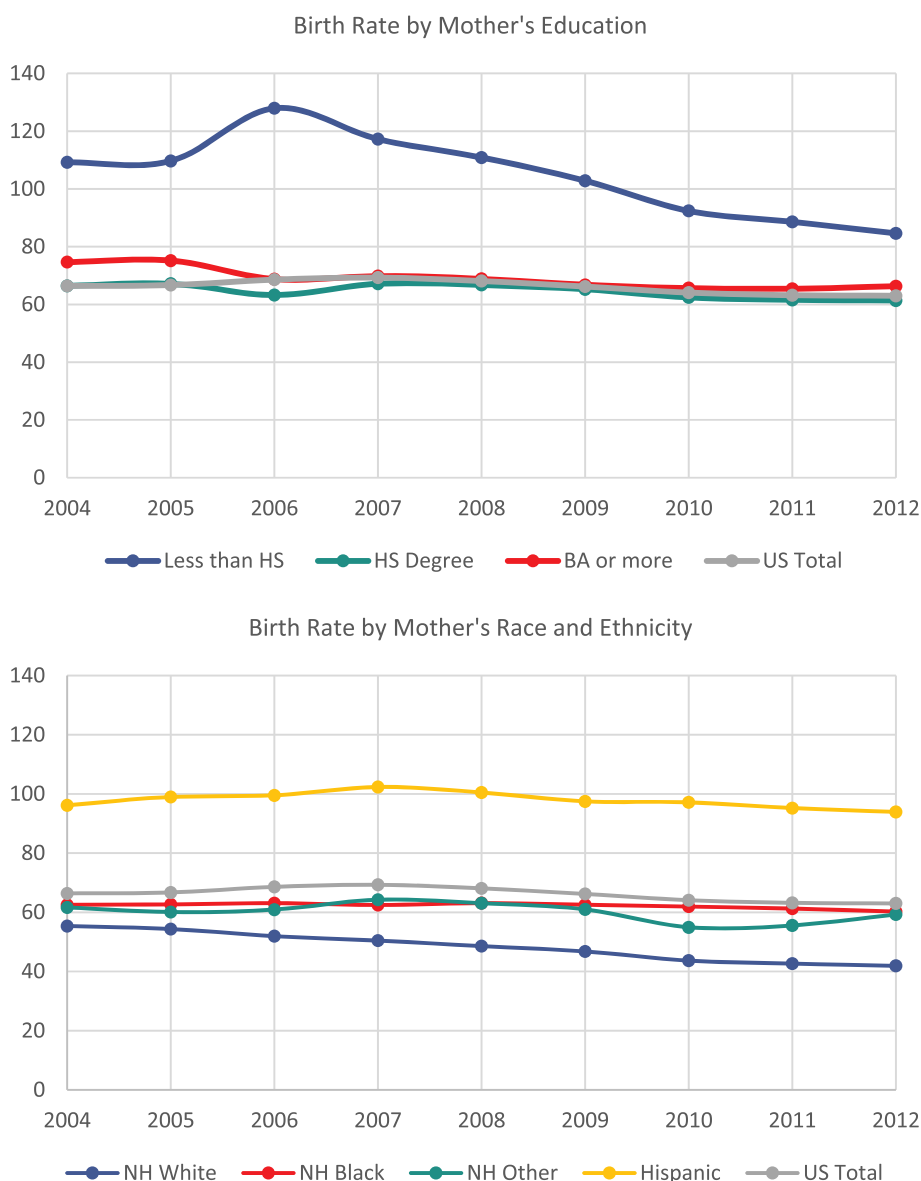


Fig. 1.

(weeks 1 through 13 6/7); second trimester is operationalized as days 98 through 195 of gestation (weeks 14 through 27 6/7). The first calendar month of gestation is considered the calendar month of conception, which was calculated by subtracting the number of gestation days from date of birth. The calendar month of conception and all calendar months that overlap with days 1 through 97 of gestation are considered the calendar months of the first trimester. All calendar months that overlap with days 98 through 195 of gestation are considered the calendar months of the second trimester. Every mother in our sample completed a first trimester and at least a part of a second trimester. The minimum gestation length was 154 days, or 22 weeks.

For the first and second trimester recession proximity measures, a trimester is coded as “during TGR,” if it overlapped with the months December 2007 through June 2009. A trimester is coded as “year before TGR,” if it did not occur “during TGR” and overlapped with the months December 2006 through November 2007. A trimester is coded as “year after TGR,” if it did not occur “during TGR” and overlapped with the months July 2009 through June 2010. All other first and second trimesters are coded as not proximal to TGR (reference category). We did not delineate recession timing measures for the third trimester because it would misidentify the timing for all pre-term births, and especially so for those mothers who did not reach the third trimester. For the a continuous, county-level measure of the average unemployment rate during the first and second trimesters, we averaged monthly BLS data that overlapped with the first and second trimesters; high correlations between employment rates during the first and second trimesters precluded examining them separately ($r = 0.97$).

Our key dependent variables include the following adverse birth outcomes: 1) a dichotomous marker of low birth-weight (<2500 g), and 2) a dichotomous marker of preterm birth (<37 weeks). We exclude multiple births from our sample, as well as records with extreme values for birthweight (<500 g or >5500 g) or gestation length (<22 weeks or ≥45 weeks). Table 1 summarizes the percent of births classified as low birthweight and pre-term birth. It also summarizes the contextual- and individual-level characteristics that we include in our analyses.

The contextual controls in our analyses include county of residence (i.e., county-fixed effects), a neighborhood disadvantage index, logged home values in the county, and percent using safety nets in the county. County and census tract of residence was identified based on geocoding of mother’s street address. The neighborhood disadvantage index is a normalized, census-tract-level index of median household income, % of population in poverty, % female-headed households, and % of population with less than a high school education, measured during the 2000 U. S. Census (for all births that occurred from 2004 to 2005) or during the 2010 U.S. Census (for all births that occurred from 2006 to 2012). Percent using safety nets is a county-level average of the number of individuals enrolled in general relief or CalWorks programs during the first and second trimester months divided by a yearly, American Community Survey (ACS) estimate of the county population during those months, and mean home values are measured during the first and second trimesters and taken from the aforementioned Zillow data.

At the individual level, we control for demographic characteristics. These demographic controls include: sex of child (0 = male, 1 = female), type of payer for birth (0 = private insurance, 1 = government, 2 = self-pay, 3 = other, 4 = unattended, none, no charge, 5 = missing), mother’s race/ethnicity (0 = Non-Hispanic White, 1 = Non-Hispanic Black, 2 = Non-Hispanic Other, 3 = Hispanic, 4 = Missing), father’s race/ethnicity (0 = Non-Hispanic White, 1 = Non-Hispanic Black, 2 = Non-Hispanic Other, 3 = Hispanic, 4 = Missing), mother’s age (0=<20, 1 = 20–34, 2 = 35–39, 3 = 40+), education level (0=<high school degree, 1 = high school degree, 2 = BA or more), nativity (0 = foreign born, 1 = U.S. born), birth parity based on the Kleinman and Kessel (1987) index (0 = first birth, 1 = low, 2 = high), and pre-pregnancy BMI (0 = underweight, 1 = normal, 2 = overweight, 3 = obese, 4 = missing). Additionally, to account for seasonal trends in unemployment and adverse birth outcomes, all of our analyses include a control for the first month of first

Table 1

VARIABLES	% of Population (N = 3,990,464)
Adverse Birth Outcomes	
Low Birthweight	4.97
Pre-term Birth	8.89
Gestational Exposure to TGR	
Unemployment Rate	8.23 (mean)
1st Tri Temporal Proximity to Recession	
Not Proximate to TGR	57.88
During TGR	11.98
Year Prior to TGR	20.93
Year Post-TGR	9.21
2nd Tri Temporal Proximity to Recession	
Not Proximate to TGR	57.19
During TGR	11.95
Year Prior to TGR	21.14
Year Post-TGR	9.72
Home Values	\$522,584.20 (mean)
Neighborhood Disadvantage Index	29.97 (mean)
% Using Safe Net	64.55 (mean)
First Month of First Trimester	
January	8.35
February	8.01
March	8.18
April	8.02
May	8.27
June	8.13
July	8.11
August	8.20
September	8.20
October	8.75
November	8.68
December	9.10
Demographic Controls	
Mother’s Education	
No HS Degree	25.48
HS Degree	49.35
BA or More	25.17
Mother’s Age	
<20 years	8.77
20–34 years	73.61
35–39 years	14.08
40 + years	3.53
Mother’s Race/Ethnicity	
NH White	28.42
NH Black	5.63
NH Other	13.78
Hispanic	51.88
Missing	0.28
Father’s Race/Ethnicity	
NH White	27.69
NH Black	6.15
NH Other	11.92
Hispanic	47.80
Missing	6.43
U.S.-born	55.77
Sex of Child: Female	48.77
Parity	
First Birth	39.62
Low	53.71
High	6.67
Payer for Birth	
Private Insurance	47.26
Government	49.19
Self-pay	2.06
Other	1.25
Unattended, None, No Charge	0.08
Missing	0.16
Body Mass Index	
Underweight	2.50
Normal	30.42
Overweight	15.72
Obese	13.15
Missing	38.22
Pregnancy Behaviors	
WIC participation	
Yes	34.74
Missing	35.17

(continued on next page)

Table 1 (continued)

VARIABLES	% of Population (N = 3,990,464)
Smoked During Pregnancy	
Yes	1.47
Missing	35.17
Weight Gain During Pregnancy	
<16 lbs	8.31
16–40 lbs	40.90
>40 lbs	11.84
Missing	38.95
Adequacy of Prenatal Care	
Inadequate	8.76
Adequate	4.25
Intermediate	34.38
Adequate Plus	52.61

trimester.

Beyond these contextual and individual controls, we also include a series of behavioral indicators in our analyses to measure the extent to which mothers' behaviors during pregnancy account for some of the variance in adverse birth outcomes associated with gestational exposure to TGR. These "pregnancy behavior indicators" include: WIC participation (0 = no, 1 = yes, 2 = missing), mother's smoking behavior during pregnancy (0 = did not smoke, 1 = smoked, 2 = missing), weight gain during pregnancy (0 = <16 lbs, 1 = 16–40 lbs, 2 = >40 lbs, 3 = missing), and adequacy of prenatal care (0 = inadequate, 1 = adequate, 2 = intermediate, 3 = adequate plus).

Statistical methods

We estimate a series of logistic regression models, with county fixed effects to account for time invariant characteristics at the county-level. The models are identified using a time-varying measure of county-level unemployment, in addition to a time-period marker of TGR which coincides with the first and second trimesters of gestation.

Results

Birth Selectivity (Q1). Overall, the total fertility rate (births per 1000 women aged 15–49) in California declined just prior to TGR in 2007, and leveled off from 2010 to 2012 (compare to US totals). Broken down by disparity sub-groups (see Fig. 1), counts of births show a general decline among those with a high school education or higher.

On the other hand, those with less than HS showed nominally increasing rates prior to 2007, with sharp declines after the start of TGR. It should also be noted that the bump in the rate in 2006 is partially a function of the change in coding employed for collection of educational data, and inferring trends during this crucial period, may affect our interpretation. Among racial/ethnic groups, while NH Whites exhibited decreasing fertility from 2004 to 2012 with no observed discontinuities at the time of the depression, NH Others and NH Blacks exhibited relatively stable rates that were independent of TGR, and finally, Hispanics exhibited increasing rates until the period of TGR, and then declining rates post-TGR. In short, the story of selective fertility was mixed in California, and highly dependent on disparity aggregations.

Next, in order to assess the effect of TGR on birth outcomes, we use a logistic regression model to measure the relationship between two indicators of gestational exposure to TGR—the temporal proximity of the first and second trimesters to TGR and county-level unemployment rate during the first and second trimesters—and two adverse birth outcomes: low birthweight and preterm birth. To minimize the issue of non-independence among infants born to the same mother, we estimate robust standard errors and restrict our analyses to singleton births, which account for approximately 97% of the births in our dataset.

Low birthweight (HQ2)

Our analysis of the effect of temporal proximity to TGR on the relative odds of low birthweight suggests that gestational exposure to TGR during the second trimester had a deleterious effect on the relative odds of low birthweight (Q2b). According to Model 1, mothers whose second trimester occurred during TGR or in the year prior to TGR exhibit a 9% and 8% higher relative odds of low birthweight, respectively. These odds increase by 1.5–17% after adjustments are made for pregnancy behaviors in Model 2, indicating that behaviors during pregnancy suppress temporal recession effects; consequently, other factors may better explain the association between gestational exposure to TGR and adverse birth outcomes (Q2c).

Model 1 of Table 2 reports that the average rate of unemployment during a mother's first and second trimesters is positively and statistically significantly associated with the odds of low birthweight (Q2a). For every 1-percentage-point increase in the unemployment rate, the relative odds of low birth-weight increases by 3%. This association remains positive and significant when adjustments are made for pregnancy behaviors in Model 2, which estimates that for every 1-percentage-point increase in the unemployment rate there is a 4% increase in the relative odds that a mother residing in that county will give birth to a child with a low birthweight. The increase in the unemployment estimates across models suggests a small suppression effect of pregnancy behaviors.

Pre-term Birth (Q2): Model 3 indicates that temporal proximity to TGR had a deleterious effect on the relative odds of pre-term birth. Mothers whose second trimester occurred during TGR or in the year prior to TGR exhibit a relative odds of preterm birth that is significantly higher than that of mothers whose second trimester was not proximate to TGR (Q2b). This finding holds when pregnancy behaviors are adjusted for in Model 4 (Q2c), though the size of the proximity effects increase slightly. We find a similar positive association between rates of unemployment and the odds of pre-term birth in Models 3–4.

Heterogeneous Effects (Q3): To assess whether the effects of TGR on the relative odds of low birthweight and pre-term birth were more concentrated in disadvantaged groups, we calculate the interaction of unemployment rate and second trimester temporal proximity to TGR with mother's education and mother's race/ethnicity. We present results from interactions with second trimester temporal proximity (Table 3) because it emerged from our analyses as the period of gestation when temporal proximity to TGR significantly affects birth outcomes; results from interactions with the first trimester are briefly discussed. We do not observe any significant statistical interaction of county-level unemployment with mother's education or mother's race/ethnicity (regression results not shown, but available upon request).

Table 3 reports the results of the interaction of second trimester temporal proximity to TGR with both mother's education (Models 1 and 3 for low birth-weight and preterm birth, respectively) and mother's race/ethnicity (Models 2 and 4). Models 1 and 3 of Table 3 indicate that temporal proximity to TGR does have a differential impact on the birth outcomes of higher and lower educated mothers. First, we find that the positive effect (on odds of low birthweight) of having a second trimester that occurs in the year of TGR is significantly less positive among college-educated mothers than it is among mothers with less than a high school degree. This confirms that higher-educated mothers are buffered, to a degree, from the deleterious effects of gestational exposure to TGR on birth outcomes. We also find that the positive effect on odds of pre-term birth of having a second trimester that occurs in the year of TGR is significantly lower among high school educated mothers and college-educated mothers – though the estimate falls short of conventional significance for college-educated mothers – than it is among mothers with less than a high school degree. Chi-squared tests indicate that adjusting for this educational heterogeneity significantly improves the fit of our model in predicting pre-term birth ($\chi^2(6) = 13.14, p = 0.04$) but does not significantly improve the fit of our model in predicting low

Table 2
Results of Logit regression measuring relationship between gestational exposure to TGR and adverse birth outcomes (odds ratios).

VARIABLES	Low Birthweight		Pre-Term Birth	
	Model 1	Model 2	Model 3	Model 4
Gestational Exposure to TGR				
Unemployment Rate	1.03*** (1.03–1.04)	1.04*** (1.03–1.05)	1.02*** (1.01–1.03)	1.03*** (1.02–1.05)
1st Tri Temporal Proximity to Recession				
Not Proximate to TGR (Ref)				
During TGR	1.02 (0.99–1.04)	1.02 (0.99–1.04)	1.01 (0.98–1.03)	1.00 (0.98–1.03)
Year Prior to TGR	0.97 (0.93–1.01)	0.96 (0.92–1.00)	1.00 (0.96–1.03)	0.97 (0.94–1.01)
Year Post-TGR	0.98 (0.95–1.01)	0.98 (0.95–1.01)	0.98 (0.95–1.01)	0.97 (0.93–1.00)
2nd Tri Temporal Proximity to Recession				
Not Proximate to TGR (Ref)				
During TGR	1.09*** (1.05–1.14)	1.11*** (1.06–1.16)	1.19*** (1.13–1.24)	1.25*** (1.18–1.33)
Year Prior to TGR	1.08** (1.02–1.14)	1.10** (1.04–1.16)	1.11*** (1.06–1.16)	1.16*** (1.10–1.23)
Year Post-TGR	0.99 (0.97–1.02)	1.00 (0.97–1.03)	1.00 (0.98–1.02)	1.01 (0.98–1.04)
Home Values (logged)	1.28*** (1.12–1.44)	1.29*** (1.11–1.49)	1.28*** (1.12–1.47)	1.34*** (1.13–1.59)
Neighborhood Disadvantage	1.73*** (1.56–1.92)	1.67*** (1.57–1.77)	1.59*** (1.48–1.71)	1.54*** (1.38–1.73)
% Using Safety Net	0.96** (0.94–0.98)	0.98 (0.96–1.01)	0.98 (0.96–1.01)	1.03 (0.99–1.08)
County of Residence Control	Yes	Yes	Yes	Yes
First Month of Trimester Control	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Pregnancy Behavior Indicators	No	Yes	No	Yes
Constant	0.00*** (0.00–0.01)	0.00*** (0.00–0.03)	0.00*** (0.00–0.01)	0.00*** (0.00–0.02)
Hosmer-Lemeshow Chi2	142.82***	42.81***	36.86***	127.25***
Observations	3,990,194	3,990,194	3,990,194	3,990,194

Note: Coefficients are reported as odds ratios. Confidence intervals reported in parentheses. Only singleton births are included in these analyses. Results for control variables are not reported in the table and can be requested from the lead author. All models control for FIPS county, first month of first trimester, and the following demographic characteristics: child's sex, type of insurance for child's birth, mother's and father's race/ethnicity, mother's age, education level, nativity, parity, and BMI. Models 2 and 4 add the following pregnancy behavior indicators: WIC participation, mother's smoking behavior during pregnancy, weight gain during pregnancy, and adequacy of prenatal care. ***p < 0.001, **p < 0.01, *p < 0.05.

birthweight (chi2(6) = 9.01, p = 0.17). Although there were no main effects for the first trimester, additional models testing interactions with first trimester (not shown) a similar pattern of low birth weight buffering for highly educated mothers during TGR. For pre-term birth, the protective impact of education on TGR exposure attains statistical significance for both high school and college educated mothers, relative to mothers with less than a high school degree.

In Model 2, we observe a small set of racial/ethnic differences in the impact of second trimester temporal proximity to TGR on the relative odds of low birthweight. Among mothers whose second trimester

Table 3
Results of Logit regression measuring relationship between gestational exposure to TGR and adverse birth outcomes (odds ratios).

VARIABLES	Low Birthweight		Pre-Term Birth	
	Model 1	Model 2	Model 3	Model 4
Gestational Exposure to TGR				
Unemployment Rate	1.04*** (1.03–1.05)	1.04*** (1.03–1.05)	1.03*** (1.02–1.05)	1.03*** (1.02–1.05)
1st Tri Temporal Proximity to Recession				
Not Proximate to TGR (Ref)				
During TGR	1.02 (0.99–1.04)	1.02 (0.99–1.04)	1.00 (0.98–1.03)	1.00 (0.98–1.03)
Year Prior to TGR	0.96 (0.92–1.00)	0.96 (0.92–1.00)	0.97 (0.94–1.01)	0.97 (0.94–1.01)
Year Post-TGR	0.98 (0.95–1.01)	0.98 (0.95–1.01)	0.97 (0.93–1.00)	0.97 (0.93–1.00)
2nd Tri Temporal Proximity to Recession				
Not Proximate to TGR (Ref)				
During TGR	1.10*** (1.05–1.16)	1.11*** (1.05–1.17)	1.26*** (1.19–1.33)	1.25*** (1.16–1.34)
Year Prior to TGR	1.11*** (1.05–1.18)	1.10** (1.04–1.17)	1.19*** (1.13–1.25)	1.16*** (1.09–1.25)
Year Post-TGR	1.02 (0.97–1.07)	0.98 (0.94–1.03)	1.03 (0.99–1.07)	1.00 (0.96–1.03)
Education				
No HS Degree (Ref)				
HS Degree	0.96*** (0.94–0.98)	0.96*** (0.95–0.98)	0.94*** (0.93–0.95)	0.93*** (0.92–0.95)
BA or More	0.80*** (0.78–0.82)	0.79*** (0.77–0.81)	0.75*** (0.73–0.77)	0.74*** (0.73–0.76)
Race/Ethnicity				
Non-Hispanic White (Ref)				
Non-Hispanic Black	1.81*** (1.77–1.86)	1.80*** (1.75–1.85)	1.36*** (1.34–1.39)	1.35*** (1.31–1.39)
Non-Hispanic Other	1.43*** (1.36–1.50)	1.44*** (1.37–1.52)	1.42*** (1.36–1.49)	1.44*** (1.38–1.50)
Hispanic	1.10*** (1.08–1.12)	1.09*** (1.07–1.12)	1.14*** (1.12–1.16)	1.14*** (1.11–1.17)
Missing	1.08 (0.97–1.20)	1.07 (0.96–1.20)	1.09 (1.00–1.18)	1.08 (0.95–1.22)
2nd Tri Proximity to TGR X Education				
During TGR X HS Degree	1.02 (0.98–1.06)		1.00 (0.96–1.04)	
During TGR X BA or More	0.99 (0.93–1.05)		0.98 (0.93–1.03)	
Prior to TGR X HS Degree	0.99 (0.97–1.01)		0.97* (0.95–1.00)	
Prior to TGR X BA or More	0.97* (0.94–1.00)		0.96 (0.93–1.00)	
Post-TGR X HS Degree	0.98 (0.92–1.05)		0.99 (0.95–1.02)	
Post-TGR X BA or More	0.95 (0.90–1.00)		0.96 (0.92–1.00)	
2nd Tri Proximity to TGR X Race/Ethnicity				
During TGR X NH Black		1.01 (0.96–1.07)		1.01 (0.96–1.07)
During TGR X NH Other		0.95** (0.91–0.98)		0.98 (0.93–1.03)
During TGR X Hispanic		1.01 (0.95–1.08)		1.01 (0.97–1.05)
During TGR X Missing		0.80* (0.66–0.98)		1.16 (0.97–1.39)

(continued on next page)

Table 3 (continued)

VARIABLES	Low Birthweight		Pre-Term Birth	
	Model 1	Model 2	Model 3	Model 4
Prior to TGR X		1.02		1.02
NH Black		(0.98–1.06)		(0.98–1.06)
Prior to TGR X		0.97		0.97
NH Other		(0.93–1.01)		(0.93–1.01)
Prior to TGR X		0.99		1.00
Hispanic		(0.95–1.04)		(0.97–1.04)
Prior to TGR X		1.07		1.02
Missing		(0.88–1.30)		(0.85–1.22)
Post-TGR X NH		1.05		1.06
Black		(0.98–1.12)		(0.99–1.13)
Post-TGR X NH		1.01		0.99
Other		(0.95–1.07)		(0.94–1.03)
Post-TGR X		1.03		1.02
Hispanic		(0.98–1.07)		(0.99–1.06)
Post-TGR X		1.10		0.89
Missing		(0.80–1.53)		(0.72–1.11)
Home Values (logged)	1.29*** (1.11–1.49)	1.29*** (1.11–1.49)	1.34*** (1.13–1.59)	1.34*** (1.13–1.59)
Neighborhood Disadvantage	1.67*** (1.57–1.78)	1.67*** (1.57–1.77)	1.55*** (1.38–1.74)	1.55*** (1.38–1.74)
% Using Safety Net	0.98 (0.96–1.01)	0.98 (0.96–1.01)	1.03 (0.99–1.08)	1.03 (0.98–1.08)
County of Residence Control	Yes	Yes	Yes	Yes
First Month of Trimester Control	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes
Pregnancy Behavior Indicators	Yes	Yes	Yes	Yes
Constant	0.00*** (0.00–0.03)	0.00*** (0.00–0.03)	0.00*** (0.00–0.02)	0.00*** (0.00–0.02)
Hosmer-Lemeshow Test	40.64***	39.89***	130.71***	134.52***
Chi2(df)	9.01	20.51	13.14*	18.98
Observations	3,990,194	3,990,194	3,990,194	3,990,194

Note: Coefficients are reported as odds ratios. Confidence intervals reported in parentheses. Only singleton births are included in these analyses. Results for control variables are not reported in the table and can be requested from the lead author. Models include the following controls: FIPS county, first month of first trimester, child’s sex, type of insurance for child’s birth, mother’s and father’s race/ethnicity, mother’s age, education level, nativity, parity, and BMI, WIC participation, mother’s smoking behavior during pregnancy, weight gain during pregnancy, and adequacy of prenatal care. ***p < 0.001, **p < 0.01, *p < 0.05.

occurred during TGR, non-Hispanic “Other” mothers (i.e. Asian-American, Native-American, or Pacific Islander mothers) exhibit an odds of low birthweight that is statistically significantly lower than that of non-Hispanic white mothers. In Model 4, we observe a similar difference between non-Hispanic white and non-Hispanic “Other” mothers but the difference is not statistically significant, so there is no clear trend in our results suggesting that the effects of temporal proximity to TGR are heavily stratified by race or ethnicity. Chi-squared tests indicate that adjusting for this racial/ethnic heterogeneity marginally improves the fit of our model in predicting low birthweight (chi2(12) = 20.51, p = 0.06).

Discussion & conclusions

The socio-economic implications of TGR were particularly profound and are just now being accounted for; the full set of health implications may not be known for years to come. However, what has become clear about the effects of TGR is that they were spatially, temporally, and demographically heterogeneous. We exploit this variation, using an individual-level measure of population health and its relationship to macro-economic trends, in an attempt to speak to prior, mixed findings

on the health effects of recessions. We also improve upon prior studies by examining variation in the effect of recessionary trends on adverse birth outcomes, a measure of population health that is particularly sensitive to local socio-economic conditions and broader changes in the political economy.

While it appears that births in CA may have declined slightly throughout the measured time-period (2004–2012), there is evidence of a larger decrease during the period of TGR (Q1). These trends varied significantly across some racial/ethnic and educational groups (Fig. 1). The potential selectivity of births is important to consider as a recent review shows an emerging trend in developed countries towards declining fertility during times of economic downturn (Orsal and Goldstein 2010). This effect has been shown to be relatively small (up to 5%) in OECD countries (Sobotka, Skirbekk, and Philipov 2010), and may have been as low as 3% in the United States during TGR (Taylor, Livingston, and Motel 2011). That said, a study of state-level variation in the unemployment rate in the United States suggests that birth outcomes improve during economic downturns due to the selection of mothers who give birth during recessions and improvements in health behaviors (Dehejia & Lleras-Muney, 2004). On the other hand, our examination of variation in birth outcomes, across demographic groups and adjusting for pregnancy behaviors, suggests that even with the possibility of birth selection, TGR remained deleterious overall, and even more so for socioeconomically disadvantaged populations.

In fact, our results show a relatively clear pattern: gestational exposure to TGR was deleteriously associated with low birthweight and pre-term birth in California. Specifically, changes in the unemployment rate were tied to increases in the relative odds of low birthweight rate (Q2a). Additionally, controlling for unemployment rates, a second trimester that was proximal (during or within a year prior to the official date) to TGR was tied to an increase in the relative odds of low birthweight and pre-term birth (Q2b). Thus, our results suggest that, above and beyond the effects of unemployment, exposure to TGR during the second trimester is negatively associated with birth outcomes. It is important to note here that the economic declines associated with TGR, including declines in economic activity and the subprime mortgage crisis, began prior to the official start date of TGR. This is likely why the effects of a second trimester that occurred in the year prior TGR are similar to the effects of one that occurred during official months of TGR. It is also worth noting that many of the infants whose second trimesters occurred just prior to the official months of TGR would have been born during TGR. Unfortunately, we are unable to disentangle these effects or tease out any cumulative effects in our analyses. Lastly, our results show that the pregnancy behaviors of those giving birth (WIC participation, smoking, pregnancy weight gain, and adequacy of prenatal care) do not account for the relationship between gestational exposure to TGR and adverse birth outcomes (Q2c). In fact, the small suppression effects suggest that women are actually faring better in terms of health behaviors (e.g. smoking, prenatal care, health insurance coverage) and/or health (e.g. weight gain during pregnancy) in periods of economic downturn, corroborating past reports of a pro-cyclical relationship between the economy and adverse health outcomes (Tapia Granados, 2005; Ruhm, 2000; Tapia; Strumpf et al., 2017).

Although not related to key hypotheses, three other results are worth highlighting. First, our recessionary results persisted net of controls for neighborhood disadvantage that were significant and important for both low birth-weight and preterm birth. With respect to home values, we observe a positive and statistically significant association between average home values in a mother’s county and the mother’s relative odds of low-birth weight and pre-term birth. While this may seem counter-intuitive, these trends may reflect a broader contextual trend in the lack of affordable housing in counties with high home values, which is a known risk factor for poor health (Maqbool, Viveiros, & Ault, 2017). In other words, while an increasing home value may be personally beneficial, increasing home values could be related to affordability concerns, which could explain their relationship

with lower birthweights and more pre-term births. Finally, the presence of social safety nets showed significant negative associations with the relative odds of low-birth weight, although these relationships became non-significant when we adjusted for mothers' pregnancy behaviors. This may be explained by public expenditure on smoking cessation during pregnancy campaigns, and expansion of WIC programs, both of which are included as mediators in our statistical models.

Finally, our results show weak evidence of broader heterogeneity with respect to the population health impacts of TGR on disadvantaged groups (Q3). Specifically, we find that temporal proximity of the second trimester to TGR is more negatively associated with the birth outcomes of mothers with less than a HS degree. However, we do not find evidence of race/ethnic differences apparent in other studies using national samples (e.g. Noelke et al., 2019). It could be that national samples mask state-level heterogeneity in the relationship between TGR and birth outcomes and that California is one such state in which race/ethnic differences are modest. Further, we utilize county level measures of unemployment and census-tract-level measures of neighborhood disadvantage, which may more fully account for race/ethnic differences in the impact of TGR.

In sum, our analysis of the relationship between TGR and adverse birth outcomes suggests that the associations between TGR and declines in population health were largely counter-cyclical and, to a modest degree, more concentrated among socially and economically disadvantaged groups. Given the well-established consequences of infant health for life-course health, our results also suggest that the impact of TGR, at the very least in California, may be long-lasting. This impact may take decades to be fully realized but gestational exposure to TGR may be associated with further health declines and heightened health disparities over the life course.

Limitations and future directions

Although the “fetal origins hypothesis” argues for the primacy of measures such as low birthweight, which is thought to be affected by poor nutrition and/or prenatal oxygen limitation (Barker, 1995)—many studies have questioned both the broad reach of birthweight for adult health and the clinical etiology of factors related to birthweight (Belbasis, Savvidou, Kanu, Evangelou, & Tzoulaki, 2016; Wilcox, 2001). Nonetheless, several twin studies and genetically-informed research designs have found that birthweight has causal effects on socio-economic attainment (Conley & Bennett, 2000; Nakamuro, Uzuiki, and Inui 2013); Black, Devereux, & Salvanes, 2005), type-II diabetes (Iliadou, Cnattingius & Lichtenstein, 2004), and coronary artery disease (Zanetti et al., 2018). In addition, the jury is still out on previous studies that found population average null main effects of birthweight on adult outcomes, as these effects may be heterogeneous within populations. For example, a study by Cook and Fletcher (2015) found the effects of birthweight on adult cognition and wages to be conditional on genes related to neuroplasticity.

Heterogenous patterns of selective fertility during TGR also raise the risk of inferring racial/ethnic or educational differences that are non-existent, though the literature is far from conclusive regarding the types of women who may have postponed birth during TGR. Cherlin et al. (2013) observe higher rates of postponement among young women and lower rates of birth among Hispanics during TGR, but these findings are largely attributable to declines in the population of Mexican immigrants. Likewise, in our study, we observe declining birth rates among Hispanic women during TGR. Given this pattern of declining Hispanic birth rates, and given that Mexican immigrants tend to experience healthier birth outcomes despite living in more disadvantaged circumstances, we should expect the diminished presence of Mexican immigrant births during TGR to lead to an overestimate of the negative effect of TGR on Hispanics. And yet, our results do not provide any systematic evidence of a differential impact of TGR on Hispanics. For this reason, we believe the risk is minimal that we are inferring relationships that are

non-existent due to the selective fertility of Hispanic mothers.

Regarding the effects of postponement among young mothers, past research suggests that young mothers are often more at-risk for adverse birth outcomes, though this pattern does not hold for African American women (Dennis & Mollborn, 2013). If it is the case that younger women, who tend to have lower levels of education and are more at-risk for adverse birth outcomes, are selecting out of our sample, we would expect the educational interactions we observe in our study (i.e. the buffering of highly educated women during TGR) to, if anything, be an underestimate of the differential effects of education. Because of this, we believe the risk is also minimal that we are inferring relationships that are non-existent due to the selective fertility of young mothers.

It is clear from our analyses that adverse birth outcomes are pro-cyclical – lower rates of unemployment during the first and second trimesters are associated with lower rates of low birthweight and pre-term birth. It is important to note, however, that gestational periods are often imprecisely recorded and measured. Furthermore, we cannot disentangle the effects of first versus second trimester unemployment on adverse birth outcomes, as the correlations between them are too high for separation ($r = 0.97$). Additionally, it is important to note that we do not measure unemployment during the third trimester, nor do we include a measure of third trimester proximity to TGR, as doing so would misidentify the timing for all pre-term births, especially for mothers who did not reach the third trimester. That said, our analyses of the relative effects of first and second trimester timing on adverse birth outcomes contribute a scant literature on trimester timing and economic downturns.

Lastly, it is clear from our analyses that behaviors during pregnancy (WIC participation, maternal smoking, weight gain, and prenatal care) were not key explanations for the relationship between gestational exposure to TGR and adverse birth outcomes, particularly low birthweight. Other potential explanatory factors, like stress, anxiety, and substance use/abuse, would be worth considering and exploring in future studies. Additionally, the role of positive social safety nets in reducing the incidence of low birth-weight needs further explication to determine which policy-level factors may be responsible.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2019.100470>.

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References

- Almond, D., & Currie, J. (2011). Killing me softly: The fetal origins hypothesis. *Journal of economic perspectives*, 25(3), 153–172.
- Barker, D. J. P. (1995). Fetal origins of coronary heart disease. *BMJ British Medical Journal*, 311(6998), 171–174.
- Belbasis, L., Savvidou, M. D., Kanu, C., Evangelou, E., & Tzoulaki, I. (2016). Birth weight in relation to health and disease in later life: An umbrella review of systematic reviews and meta-analyses. *BMC Medicine*, 14, 148.
- Black, S. E., Devereux, P. J., & Salvanes, K. G. (2005). “From the cradle to the labor market? The effect of birth weight on adult outcomes.”. IZA DP No. 1864.
- Bruckner, T. A., Mortensen, L. H., & Catalano, R. A. (2016). Spontaneous pregnancy loss in Denmark following economic downturns. *American Journal of Epidemiology*, 183(8), 701–708.
- Buescher, P. A., Taylor, K. P., Davis, M. H., & Bowling, J. M. (1993). The Quality of the New Birth Certificate Data: A Validation Study in North Carolina. *American Journal of Public Health*, 83, 1163–1165.
- Buka, S. L., Brennan, R. T., Rich-Edwards, J. W., Raudenbush, S. W., & Earls, F. (2003). Neighborhood support and the birth weight of urban infants. *American Journal of Epidemiology*, 157(1), 1–8.
- Burgard, S. A., Ailshire, J. A., & Kalousova, L. (2013). The Great Recession and health: People, populations, and disparities. *The Annals of the American Academy of Political and Social Science*, 650(1), 194–213.

- Burgard, S. A., Brand, J. E., & House, J. S. (2007). Toward a better estimation of the effect of job loss on health. *Journal of Health and Social Behavior*, 48(4), 369–384.
- Burgard, S. A., Brand, J. E., & House, J. S. (2009). Perceived job insecurity and worker health in the United States. *Social Science & Medicine*, 69(5), 777–785.
- Burris, H. H., & Hacker, M. R. (2017). Birth outcome racial disparities: A result of intersecting social and environmental factors. *Seminars In Perinatology (Philadelphia)*, 41(6), 360–366.
- Carlson, K. (2015). Fear itself: The effects of distressing economic news on birth outcomes. *Journal of Health Economics*, 41, 117–132.
- Catalano, R., et al. (2011). The health effects of economic decline. *Annual Review of Public Health*, 32, 431–450.
- Catalano, R., Hansen, H. T., & Hartig, T. (1999). The ecological effect of unemployment on the incidence of very low birthweight in Norway and Sweden. *Journal of Health and Social Behavior*, 422–428.
- Catalano, R., & Serxner, S. (1992). The effect of ambient threats to employment on low birth weight. *Journal of Health and Social Behavior*, 33, 363–377.
- Catalano, R., Zilko, C. E. M., Saxton, K. B., & Bruckner, T. (2010). Selection in utero: A biological response to mass layoffs. *American Journal of Human Biology*, 22(3), 396–400.
- Charles, K. K., & DeCicca, P. (2008). Local labor market fluctuations and health: Is there a connection and for whom? *Journal of Health Economics*, 27(6), 1532–1550.
- Chay, K. Y., & Greenstone, M. (2003). The impact of air pollution on infant mortality: Evidence from geographic variation in pollution shocks induced by a recession. *Quarterly Journal of Economics*, 118(3), 1121–1167.
- Cherlin, A., Cumberworth, E., Morgan, S. P., & Wimer, C. (2013). The effects of the Great Recession on family structure and fertility. *The Annals of the American Academy of Political and Social Science*, 650(1), 214–231.
- Conley, D., & Bennett, N. G. (2000). Is biology destiny? Birth weight and life chances. *American Sociological Review*, 65(3), 458–467.
- Cook, C. J., & Fletcher, J. M. (2015). Understanding heterogeneity in the effects of birth weight on adult cognition and wages. *Journal of Health Economics*, 41, 107–116.
- Corman, H., & Chaikind, S. (1993). *The effect of low birthweight on the health, behavior, and school performance of school-aged children (No. w4409)*. National Bureau of Economic Research.
- Currie, J., & Hyson, R. (1999). Is the impact of health shocks cushioned by socioeconomic status? The case of low birthweight. *The American Economic Review*, 89(2), 245–250.
- Currie, J., & Tekin, E. (2011). *Is the foreclosure crisis making us sick?*. Unpublished Manuscript.
- Dehejia, R., & Lleras-Muney, A. (2004). Booms, busts, and babies' health. *Quarterly Journal of Economics*, 119(3), 1091–1130.
- Dennis, J. A., & Mollborn, S. (2013). Young maternal age and low birth weight risk: An exploration of racial/ethnic disparities in the birth outcomes of mothers in the United States. *The Social Science Journal*, 50(4), 625–634. <https://doi.org/10.1016/j.soscij.2013.09.008>.
- Dooley, D., & Prause, J. (2005). Birth weight and mothers' adverse employment change. *Journal of Health and Social Behavior*, 46(2), 141–155.
- Dudel, C., & Myrskylä, M. (2017). Working life expectancy at age 50 in the United States and the impact of the Great Recession. *Demography*, 54(6), 2101–2123.
- Edwards, R. (2008). Who is hurt by procyclical mortality? *Social Science & Medicine*, 67(12), 2051–2058.
- Eiríksdóttir, V. H., Ásgeirsdóttir, T. L., Bjarnadóttir, R. I., Kaestner, R., Cnattingius, S., & Valdimarsdóttir, U. A. (2013). Low birth weight, small for gestational age and preterm births before and after the economic collapse in Iceland: A population based cohort study. *PLoS One*, 8(12), e80499.
- Elsby, M. W., Hobijn, B., & Sahin, A. (2010). *The labor market in the Great Recession (No. w15979)*. National Bureau of Economic Research.
- Ensor, T., Cooper, S., Davidson, L., Fitzmaurice, A., & Graham, W. J. (2010). The impact of economic recession on maternal and infant mortality: Lessons from history. *BMC Public Health*, 10(1), 727.
- Finch, B. K., Lim, N., Perez, W., & Do, P. (2007). Toward a population health model of segmented assimilation: The case of low birth-weight in los angeles. *Sociological Perspectives*, 50(3), 445–468.
- Fisher, E. S., LoGerfo, J. P., & Daling, J. R. (1985). Prenatal care and pregnancy outcomes during the recession: The Washington state experience. *American Journal of Public Health*, 75(8), 866–869.
- Gerdtham, U.-G., & Ruhm, C. J. (2006). Deaths rise in good economic times: Evidence from the OECD. *Economics and Human Biology*, 4, 298–316.
- Goldstein, J. R., Kreyenfeld, M., Jasilioniene, A., & Órsal, D. K. (2013). Fertility reactions to the “great recession” in europe: Recent evidence from order-specific data. *Demographic Research*, 29, 85–104.
- Gortmaker, S., & Wise, P. (1997). The first injustice: Socioeconomic disparities, health services technology, and infant mortality. *Annual Review of Sociology*, 23, 147–170.
- Gould Ellen, I., & Dastrup, S. (2012). Housing and the great recession. *Stanford Center on Poverty and Inequality*, October. Accessed August, 12, 2017.
- Grusky, D. B., Western, B., & Wimer, C. (Eds.). (2011). *The great recession*. Russell Sage Foundation.
- Hack, M., Flannery, D. J., Schluchter, M., Cartar, L., Borawski, E., & Klein, N. (2002). Outcomes in young adulthood for very low- birth-weight infants. *New England Journal of Medicine*, 346(3), 149–157.
- Hayward, M. D., & Gorman, B. K. (2004). The long arm of childhood: The influence of early-life social conditions on men's mortality. *Demography*, 41(1), 87–107.
- Holahan, J. (2010). The 2007–09 recession and health insurance coverage. *Health Affairs*, 30(1), 145–152.
- Hoynes, H. W., Miller, D. L., & Schaller, J. (2013). The great recession and greater disparities in employment and earnings. *Center for Poverty Research Policy Brief*, 1(7).
- Huang, J., Birkenmaier, J., & Kim, Y. (2014). Job loss and unmet health care needs in the economic recession: Different associations by family income. *American Journal of Public Health*, 104(11), e178–e183.
- Hummer, R. A. (1993). Racial differentials in infant mortality in the U.S.: An examination of social and health determinants. *Social Forces*, 72(2), 529–554.
- Iliadou, A., Cnattingius, S., & Lichtenstein, P. (2004). Low birthweight and type 2 diabetes: A study on 11,162 Swedish twins. *International Journal of Epidemiology*, 33, 948–953.
- Juárez, S., Revuelta-Eugercios, B. A., Ramiro-Fariñas, D., & Viciano-Fernández, F. (2014). Maternal education and perinatal outcomes among Spanish women residing in southern Spain (2001–2011). *Maternal and Child Health Journal*, 18(8), 1814–1822.
- Kleinman, J. C., & Kessel, S. S. (1987). Racial differences in low birth weight: Trends and risk factors. *New England Journal of Medicine*, 317(12), 749–753.
- Kneebone, E., & Garr, E. (2010). The landscape of recession: Unemployment and safety net services across urban and suburban America. *Metropolitan Policy Program at Brookings*, March 2010.
- Lantz, Paula and Melissa Partin. 1994. Prenatal and Infant Health Indicators. Conference on Indicators of Children's Well-Being, Rockville, MD, Nov 17-18 1994.
- Lee, S., et al. (2004). Prospective study of job insecurity and coronary heart disease in US women. *Annals of Epidemiology*, 14(1), 24–30.
- Maqbool, N., Viveiros, J., & Ault, M. (2017). “The impacts of affordable housing on health: A research summary.” *Insights from housing policy research*. Center for Housing Policy.
- Margerison, C. E., Luo, Z., & Li, Y. (2019). Economic conditions during pregnancy and preterm birth: A maternal fixed-effects analysis. *Paediatric and perinatal epidemiology*, 33(2), 154–161.
- Margerison Zilko, C. E. (2010). Economic contraction and birth outcomes: An integrative review. *Human Reproduction Update*, 16(4), 445–458.
- Margerison-Zilko, C. (2014). Economic contraction and maternal health behaviors during pregnancy in a national sample of US women. *Annals of Epidemiology*, 24(6), 432–440.
- Margerison-Zilko, C., Goldman-Mellor, S., Falconi, A., & Downing, J. (2016). Health impacts of the great recession: A critical review. *Current epidemiology reports*, 3(1), 81–91.
- Margerison-Zilko, C. E., Li, Y., & Luo, Z. (2017). Economic conditions during pregnancy and adverse birth outcomes among singleton live births in the United States, 1990–2013. *American Journal of Epidemiology*, 186, 1131–1139.
- Markides, K. S., & Coreil, J. (1986). The health of Hispanics in the southwestern United States: An epidemiologic paradox. *Public Health Reports*, 101(3), 253–265.
- Martikainen, P. T., & Valkonen, T. (1996). Excess mortality of unemployed men and women during a period of rapidly increasing unemployment. *The Lancet*, 348(9032), 909–912.
- Modrek, S., & Cullen, M. R. (2013). Health consequences of the ‘great recession’ on the employed: Evidence from an industrial cohort in aluminum manufacturing. *Social Science & Medicine*, 92, 105–113.
- Morenoff, J. D. (2003). Neighborhood mechanisms and the spatial dynamics of birth weight. *American Journal of Sociology*, 108(5), 976–1017.
- National Center for Health Statistics, LA Fingerhut and JC Kleinman. 1985. Comparability of Reporting Between the Birth Certificate and the 1980 National Natality Survey. *Vital and Health Statistics, Series 2, No. 99*.
- Nakamuro, M., Uzuki, U., & Inui, T. (2013). The effects of birth weight: Does fetal origin really matter for long-run outcomes. *Economics Letters*, 121, 53–58.
- Noelke, C., Chen, Y. H., Osypuk, T. L., & Acevedo-Garcia, D. (2019). Economic downturns and inequities in birth outcomes: Evidence from 149 million US births. *American Journal of Epidemiology*, 188(6), 1092–1100.
- Noland, R. B., & Zhou, Y. (2017). Has the great recession and its aftermath reduced traffic fatalities? *Accident Analysis and Prevention*, 98, 130–138.
- Orsal, D. D. K., & Goldstein, J. R. (2010, April). The increasing importance of economic conditions on fertility. In *Annual Meeting of the Population Association of America, Dallas, Texas*.
- O'Campo, P., Xue, X., Wang, M.-C., & O'Brien Caughy, M. (1997). Neighborhood risk factors for low birthweight in Baltimore: A multilevel analysis. *American Journal of Public Health*, 87(7), 1113–1118.
- Pearl, M., Braveman, P., & Abrams, B. (2001). The relationship of neighborhood socioeconomic characteristics to birthweight among 5 ethnic groups in California. *American Journal of Public Health*, 91(11), 1808–1814.
- Piper, J. M., Mitchel, E. F., Snowden, M., Hall, C., Adams, M., & Taylor, P. (1993). Validation of 1989 Tennessee Birth Certificates using Maternal and Newborn Hospital Records. *American Journal of Epidemiology*, 137, 758–768.
- Querec LJ. 1980. Comparability of Reporting on Birth Certificates and National Natality Survey Questionnaires. *Vital and Health Statistics: Series 2 No 83*.
- Rich-Edwards, J. W., Kleinman, K., Michaels, K. B., Stampfer, M. J., Manson, J. E., Rexrode, K. M., et al. (2005). Longitudinal study of birth weight and adult body mass index in predicting risk of coronary heart disease and stroke in women. *BMJ British Medical Journal*, 330, 1115–1118.
- Risnes, K. R., Vatten, L. J., Baker, J. L., Jameson, K., Sovio, U., Kajantie, E., & Sundh, V. (2011). Birthweight and mortality in adulthood: A systematic review and meta-analysis. *International Journal of Epidemiology*, 40(3), 647–661.
- Riva, M., Bamba, C., Easton, S., & Curtis, S. (2011). Hard times or good times? Inequalities in the health effects of economic change. *International Journal of Public Health*, 56(1), 3–5.
- Roberts, E. M. (1997). Neighborhood social environments and the distribution of low birthweight in Chicago. *American Journal of Public Health*, 87(4), 597–603.
- Ross, C. E., & Mirowsky, J. (1995). Does employment affect health? *Journal of Health and Social Behavior*, 36, 230–243.

- Ruhm, C. J. (2000). Are recessions good for your health. *Quarterly Journal of Economics*, 115, 617–650.
- Schneider, D. (2015). The great recession, fertility, and uncertainty: Evidence from the United States. *Journal of Marriage and Family*, 77(5), 1144–1156.
- Smith, L. P., Ng, S. W., & Popkin, B. M. (2014). Resistant to the recession: Low-income adults' maintenance of cooking and away-from-home eating behaviors during times of economic turbulence. *American Journal of Public Health*, 104(5), 840–846.
- Sobotka, T., Skirbekk, V., & Philipov, D. (2011). Economic recession and fertility in the developed world. *Population and development review*, 37(2), 267–306.
- Strully, K. W. (2009). Job loss and health in the U.S. Labor market. *Demography*, 46(2), 221–246.
- Strumpf, E. C., Charters, T. J., Harper, S., & Nandi, A. (2017). Did the great recession affect mortality rates in the metropolitan United States? Effects on mortality by age, gender and cause of death. *Social Science & Medicine*, 189, 11–16.
- Sullivan, D., & Von Wachter, T. (2009). Job displacement and mortality: An analysis using administrative data. *Quarterly Journal of Economics*, 124(3), 1265–1306.
- Tapia Granados, J. A. (2005). Increasing mortality during the expansions of the US economy, 1900- 1996. *International Journal of Epidemiology*, 34(6), 1194–1202.
- Taylor, Paul, Gretchen Livingston, and Seth Motel. 2011. In a Down Economy, Fewer Births. Pew Research Center:Social and Demographic Trends: October 2011.
- Wilcox, A. J. (2001). "On the importance –and the unimportance—of birthweight. *International Journal of Epidemiology*, 30, 1233–1241.
- Yu, W.-hsin, & Sun, S. (2018). Fertility responses to individual and contextual unemployment: Differences by socio-economic background. *Demographic Research*, 39(35), 927–962.
- Zanetti, D., Tikkanen, E., Gustafsson, S., Priest, J. R., Burgess, S., & Ingelsson, E. (2018). Birthweight, type 2 diabetes mellitus, and cardiovascular disease. *Genomic and Precision Medicine*, 11, e002054.