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Short Report

Rising inequality of infant health in the U.S.

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ABSTRACT

Has infant health inequality narrowed or grown in recent decades? Inequality may have narrowed due to expanded medical insurance coverage and greater knowledge about fetal health. However, greater income inequality may have reduced health for births to the most economically disadvantaged mothers, leading to growing infant health inequality. We use administrative birth certificate data for over 22 million births to examine trends in inequality of infant health from 1989 to 2018 in the U.S. This period allows us to consider how contextual factors – such as passage of the Affordable Care Act, changing demographics, the Great Recession, or delayed impacts of rising income inequality – may have altered infant health inequality. We assess gaps in infant health by maternal race, marital status, and education. Following previous research, we also examine gaps between the most economically advantaged mothers – married, white mothers with a college degree – and the most economically disadvantaged mothers – single, Black mothers without a high school degree. Results reveal that inequality of infant health has increased since 2010.

Introduction

Poor infant health is consequential for a host of later life outcomes from increased mortality risk in early childhood, to a greater risk of academic failure in adolescence, to lower earnings in adulthood (Black et al., 2007; Conley et al., 2003; Royer, 2009). Evidence suggests that maternal economic disadvantage is a strong predictor of poor infant health (Currie & Moretti, 2003; Kandel et al., 2009; Kimbro et al., 2008; Schoendorf et al., 1992). However, recent studies have found that birth outcomes to the most economically disadvantaged mothers have improved over the past few decades (Aizer & Currie, 2014; Currie & Gruber, 2001; Lin, 2009), reducing the inequality children face at birth. Explanations for narrowing infant health gaps include rising healthcare coverage rates for the most economically disadvantaged mothers and growing knowledge about factors impacting fetal health across socioeconomic gradients (Aizer & Currie, 2014; Currie & Gruber, 2001; Lin, 2009).

At the same time, researchers have asserted that infant health inequality has grown over the past few years, in concert with increasing income inequality, now at a 50-year high in the U.S. (Odgers, 2015; Olson et al., 2010; Pickett & Wilkinson, 2015). This argument suggests that growing income inequality is particularly consequential for infant health at birth. Infant health varies by income inequality in part because countries that permit large income disparities, relative to more egalitarian countries, tend to invest less in social supports and programs for parents and infants from the most disadvantaged backgrounds. Adjudicating between increasing or decreasing infant health inequality has implications both for understanding the source of health disparities and for targeting policy interventions to address gaps in infant health outcomes.

In this study, we draw on population-level national birth data from the National Vitality Statistics System to examine the most recent trends in infant health inequality and assess whether gaps are narrowing or widening by maternal race, marital status, or education. Combining these axes of inequality, we also examine trends in infant health inequality by economic standing. Although these data provide rich information on birth outcomes, they do not contain income data. Following previous literature (Aizer & Currie, 2014), our proxy measure of economic standing is a combination of maternal race, marital status, and educational attainment, which are each independently associated with income (Hoffman, 1977; Schnittker, 2004). As in previous research, we assess gaps in infant health between the most economically advantaged mothers – married, white mothers with a college degree – and the most economically disadvantaged mothers – single, Black mothers without a high school degree (Aizer & Currie, 2014). Prior work has noted that Black mothers, single mothers, and mothers with low

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levels of educational attainment are all more likely to be economically disadvantaged and that these three groups are also more likely to give birth to infants with poor health (Marra et al., 2011; Orchard & Price, 2017; Strully et al., 2010). Analysis of Census Bureau data by Aizer and Currie found that the average household income for white, married, college-educated mothers from 2010 to 2012 was $120,655, compared to $16,497 for Black, single mothers with less than a high school degree. This stark difference in average income suggests that a combination of race, marital status, and educational attainment are prudent proxies for economic advantage and disadvantage.

We use the most recently available population-level birth certificate data to examine infant health trends from 1989 to 2018. This time range allows us to consider how large-scale contextual factors – such as the passage of the Affordable Care Act (ACA), changing demographics, the Great Recession, or delayed impacts of rising income inequality – may have altered or reshaped infant health inequality trends in ways not previously examined.

Why infant health trends may be changing

There are several reasons that trends in infant health may have changed in the past decade, including economic, demographic, policy, and information changes.

Economic, demographic, and policy changes

Prior research found narrowing gaps in infant health from 1989 to 2010, comparing births to economically advantaged and disadvantaged mothers. Authors who found narrowing infant health gaps offered a range of explanations from greater knowledge and dissemination about fetal health matters to increasing infant medical care for the most disadvantaged families (Aizer & Currie, 2014; Lin, 2009). For example, enactment of the Affordable Care Act in 2010 expanded healthcare access to increasing numbers of low-income families (Chen et al., 2016) and may have helped to reduce infant health inequality.

Second, changing demographics might also contribute to decreasing infant health inequality. Hispanics are one of the fastest-growing racial/ethnic groups and have the highest fertility rate among women in the United States (Martin et al., 2019). Hispanic mothers also tend to have healthier babies than would otherwise be predicted given their average levels of socioeconomic standing (Lara et al., 2005; Scribner & Dwyer, 1989). When comparing births to economically advantaged and disadvantaged mothers, infant health inequality could narrow over time if an increasing proportion of births in the disadvantaged category are births to Hispanic mothers, who tend to have healthier infants than expected given their socioeconomic characteristics (Shaw & Pickett, 2013). Similarly, if infants born to Hispanic white, married, and college-educated mothers are not as advantaged as infants born to their non-Hispanic white peers, then increasing numbers of Hispanic births could also narrow infant health gaps. Approximately 7% of births were to Hispanic mothers over the years of our analyses (1989–2018), including 6.6% of births to economically disadvantaged mothers and 7.4% of births to economically advantaged mothers. In other words, among births to unmarried Black mothers with less than a high school degree, 6.6% were to Hispanic mothers. A slightly higher proportion (7.4%) of births to married white mothers with a college degree were to Hispanic mothers. These proportions of Hispanic births increased over time. In years since 2010, 12.9% of births in the economically disadvantaged category and 9.2% in the advantaged category were to Hispanic mothers. If infants born to Hispanic mothers tend to be healthier (Lara et al., 2005; Scribner & Dwyer, 1989), then the greater increase in Hispanic births among the economically disadvantaged category could yield a flatter trend in inequality than would have occurred without the increasing proportion of births to Hispanic mothers.

Alternatively, infant health inequality may have persisted or increased since 2010. Some scholars have linked increasing income inequality with increasing infant health inequality (Elgar et al., 2015; Manduca, 2018; Olson et al., 2010). For example, Olson and colleagues (Olson et al., 2010) found that income and income inequality (measured using the Gini coefficient) explained a substantial proportion of variation in rates of preterm birth, low-birth weight, and very low birth weight infants. Evidence of a relationship between income inequality and health are not isolated to the U.S. context. International studies have documented the association between increased socioeconomic disparities and worsening health outcomes for adolescents (Elgar et al., 2015). The consensus among these studies is not only that increasing economic inequality portends worsening infant health outcomes, but that income inequality impacts infant health by further disadvantaging those at the lowest end of the income distribution. Thus, factors that exacerbate inequality, such as the Great Recession, may exacerbate both income and infant health inequality. In the U.S., income disparities between Black and white families have remained relatively stable since the 1960s (Manduca, 2018). However, the Great Recession was especially impactful for Black and low-income families, who experienced a slower recovery and longer-lasting effects (McKernan et al., 2014; van Kempen et al., 2016; Wolff, 2017, p. 24085). Thus, the Great Recession, increasing income inequality, and persistent racial income disparities may have cumulatively put economically disadvantaged mothers at greater risk for poor infant health outcomes since 2010.

Information changes

Beyond these economic and policy factors, advancement and dissemination in prenatal medical knowledge might also predict recent changes in infant health inequality. For example, one explanation for declining inequality in infant health is related to better maternal knowledge about fetal health (Aizer & Currie, 2014). This explanation is rooted in a risk-factor approach that considers the source of disease to lie between some distal cause (such as socioeconomic status [SES]) and the outcome of interest (infant health). If infant health disparities by SES are due to a lack of maternal knowledge among low-SES mothers, then providing these mothers with more information would eliminate health disparities.

On the other hand, if SES is a fundamental cause of infant health inequalities, then identifying interventions that are not resource-dependent becomes increasingly important. The theory suggests that those in SES-advantaged positions have greater access to flexible resources, which they use to maintain better health, relative to those in lower-SES positions (Phelan et al., 2010). Phelan, Link, and Tehranifar (Phelan et al., 2010) suggest that SES inequalities are likely to persist when interventions focus on individual risk factors. For example, when practitioners recommend that pregnant women take a folic acid supplement, access to this information and uptake of the recommendation is likely to follow an SES gradient. However, adding folic acid to cereal or foods that women frequently eat is less likely to depend on one's flexible resources and can contribute to healthier outcomes across the SES distribution. This universal approach considers how to intervene on societal factors that put individuals at risk for certain diseases or poor health outcomes, referred to as risk of risks, rather than intervening on individual-level factors (Phelan et al., 2010). Thus, empirically adjudicating between these divergent futures — narrowing or increasing infant health inequalities — with more recent data holds implications for how policies or public health efforts could most effectively address infant health disparities.

We test four distinct hypotheses related to trends in infant health inequality since 2010, drawing on the above review. We focus on changes starting in 2011 but analyze birth certificate data since 1989 for comparison with previous research (Aizer & Currie, 2014). Focusing on changes after 2010 allows us to consider a range of contextual factors that may have altered infant health inequality trends and were not accounted for in previous research.

First, we test the prediction that declining infant health inequality would persist after 2010. Increasing access to medical care for the most vulnerable mothers may attenuate the relationship between income and infant health at birth. Recent estimates have documented that the Affordable Care Act dramatically reduced the number of low-income uninsured families, with the greatest impact on low to moderate-income individuals (Obama, 2016). If increasing access to medical care benefited disadvantaged mothers, we would expect infant health gaps to narrow between economically advantaged and disadvantaged mothers after the passage of the Affordable Care Act in 2010. *Hypothesis 1*: Inequality of infant health decreased after 2010.

Demographic changes may have altered trends in inequality of infant health. The greater increase in Hispanic representation among the economically disadvantaged category could yield a flatter inequality trend than would have occurred without the increasing proportion of births to Hispanic mothers. If inequality declined after 2010 because of this demographic change, then excluding births to Hispanic mothers should reveal persistent inequality. *Hypothesis 2*: Inequality of infant health remained constant after 2010 when excluding births to Hispanic mothers.

If SES is a fundamental cause of health disparities, then inequality of infant health should increase (not decrease) with greater access to medical information, technology, and health care. Because resources such as medical information are more flexibly leveraged by the socio-economically advantaged, new information or technology can increase rather than decrease inequality. *Hypothesis 3*: Inequality of infant health increased after 2010.

If SES is a fundamental cause of health inequality, both the extent of economic inequality and unequal ability to leverage new information or policies should contribute to changes in health inequality. Alternatively, inequality of infant health could depend largely on the degree of economic inequality. In that case, controlling for aggregate economic inequality measures (national poverty rate, Gini coefficient of income inequality) should explain a rising trend in infant health inequality. *Hypothesis 4*: Inequality of infant health did not increase after 2010 when controlling for aggregate economic inequality measures.

Materials and methods

Data

We use annual U.S. administrative birth records from the National Vital Statistics System (NVSS) to examine trends in inequality of infant health by socioeconomic status from 1989 to 2018. Collected by the Centers for Disease Control and Prevention, these data provide the most complete and accurate information on live births in the U.S.

We use U.S. Census Bureau data on the national poverty rate and the Gini coefficient of income inequality from 1989 to 2018. These data provide information on national economic inequality to test *Hypothesis 4*.

Sample

As in previous research (Aizer & Currie, 2014), we limit the sample to singleton live births to mothers ages 19–39 and calculate annual, aggregate infant health measures separately by maternal race, marital status, and education. Thus, we exclude multiple births (e.g., twins) and births to mothers outside of typical child-bearing age. To make results comparable with previous work (Aizer & Currie, 2014), we compare aggregate infant health among births to economically advantaged mothers (White, married, and with a college degree) and economically disadvantaged mothers (Black, unmarried, and with less than a high school degree). To build on previous work, we also disaggregate all analyses to compare trends in infant health separately by maternal race (white, Black), marital status (married, unmarried), and education (less than a high school degree, college degree). The above exclusions result in a total sample of 2,190,085 births to economically disadvantaged mothers and 20, 325, 896 births to economically advantaged mothers. The number of births disaggregated by race, marital status, and education are: 22, 344, 662 Black; 121, 562, 450 white; 40, 899, 396 unmarried; 105, 117, 060 married; 23, 562, 028 less than high school; 32, 314, 912 college degree.

Main analyses include births to Hispanic mothers. Race and ethnicity are distinct concepts in the U.S. Federal and state governments consider Hispanic an ethnic rather than racial category (Office of Management and Budget, 1997). Consistent with other government-collected data (e.g., U.S. Census), NVSS birth data gather information about parental race separately from information about Hispanic ethnicity. Racial categories and Hispanic ethnicity are not mutually exclusive. For example, 6.6% of births to unmarried Black mothers with less than a high school degree were to Hispanic mothers. In comparison, 7.4% of births to married white mothers with a college degree were to Hispanic mothers. To test hypothesis 2, we repeat the main analyses when excluding births to Hispanic mothers from both the economically advantaged and disadvantaged groups (i.e. non-Hispanic White, married, and with a college degree compared to non-Hispanic Black, unmarried, without a high school degree).

An earlier study (Aizer & Currie, 2014) excluded births in 14 states with inconsistent education information (AL, AK, AZ, AR, CT, HI, ME, MA, MN, MS, NJ, RI, VA, WV). Main analyses include births in all states, but results are consistent when excluding births in those 14 states.

Measures

Year indicates the year of birth. We extend the previous literature by focusing on trends since 2010. To do so, we create a measure of years since 2010, calculated as year minus 2010 and coded zero for years before 2010.

We measure infant health using rates of low birth weight (<2500 g), very low birth weight (<1500 g), and preterm birth (gestational length <37 weeks), in addition to mean values of birth weight and gestational length, and standard deviation measures of birth weight and gestational length. We calculate annual aggregate values for each of these infant health measures, separately by maternal economic advantage category. These aggregate measures allow us to examine trends in rates of poor infant health outcomes, as well as the mean and dispersion of infant health measures.

Maternal race, marital status, education, and ethnicity are self-reported on birth certificates and recorded in the NVSS birth data. We examine births to Black or white mothers, married or unmarried mothers, and mothers with less than a high school degree or mothers with a Bachelor's degree or higher. Race is reported independently of Hispanic ethnicity and Black or white mothers may identify as Hispanic or non-Hispanic in the main analyses. To test hypothesis 2, we also create separate race categories that are exclusive of Hispanic mothers (non-Hispanic Black, non-Hispanic white). Throughout the paper, Black and white categories include mothers regardless of ethnicity unless non-Hispanic is specified.

We proxy for economic standing by combining these axes of advantage and disadvantage, which are each independently associated with income (Hoffman, 1977; Schnittker, 2004). Economically advantaged mothers include white, married mothers with a BA. Economically disadvantaged mothers include Black, unmarried mothers with less than a high school degree. Mean household income in 2010–2012 (Aizer & Currie, 2014) was over seven times larger among the economically advantaged group ($120,655) than the economically disadvantaged group ($16,497), which suggests that the combination of race, marital status, and educational attainment provides a useful proxy for economic standing.

Analyses

We predict annual aggregate infant health measures separately by maternal category (race, marital status, education, or SES category) in ordinary least squares (OLS) regression models controlling for the overall time trend (year). To test whether trends have changed since 2010, we add the measure of years since 2010. For example, Equation (1) predicts the rate of low birth weight among economically disadvantaged (low-SES) births with the overall time trend (year) and years since 2010. The coefficient for years since 2010 (β_2) tests whether the low birth weight trend differed significantly after 2010 among economically disadvantaged births. We predict each infant health measure separately by maternal category. For example, when predicting percent low birth weight among economically advantaged births, β_2 similarly tests whether the trend differed significantly after 2010 in the advantaged category.

$$\%\ Low\ Birth\ Weight_i^{low-SES} = \alpha + \beta_1 Year_i + \beta_2 Years\ Since\ 2010_i + \varepsilon_i \tag{1}$$

Tests of model fit when adding years since 2010 provide further evidence of a different trend in infant health after 2010. We provide changes in AIC and BIC statistics of model fit, as well as results of log likelihood ratio tests, when adding years since 2010 to the baseline model. These measures provide statistical tests of whether controlling for years since 2010 improves model fit. Akaike (AIC) and Bayesian information criteria (BIC) (as well as log likelihood ratios) are used to indicate models balancing data fit and parsimony (Raftery 1986, 1995). In both cases, lower values indicate better fit. BIC may overvalue parsimony or simpler models (Weakliem 1999); it is, therefore, important to include multiple statistics in considering model fit. Better fit statistics in models that include years since 2010 would suggest that including the alternative trend (years since 2010) provides a better prediction of the observed data and a better explanation of variation in infant health, making it worth the reduced parsimony.

Sensitivity analyses repeat the above analyses when including an indicator for years after 2010 to ensure estimates do not simply reflect a one-time or stable change in infant health after 2010. We use standard errors that are robust to heteroscedasticity in all models.

Results

Aggregate mean values of annual observations by maternal race, marital status, and education – pooled across all years 1989–2018 – are shown in Appendix Table S1, Panel A. Panel B provides descriptive statistics for all SES-year observations and separately by maternal SES category. Infant health measures are consistently poorer among births to Black, unmarried mothers with less than a high school degree, compared to their more economically advantaged counterparts. Furthermore, standard deviations of birth weight and gestational length are higher among births to economically disadvantaged mothers, suggesting greater variation in infant health outcomes than among births to advantaged mothers.

Table 1 shows the results of models predicting annual infant health measures. Controlling for the overall time trend, results in Panel A show that health among births to Black mothers was improving before 2010. After 2010, it remained stable or improved on some measures. For example, the rate of very low birth weight was declining by about 0.1% per decade before 2010 and declined slightly faster (0.4% per decade) after 2010. Mean gestational length also improved after 2010 among Black births. Panel B shows results among births to white mothers and suggests that although infant health outcomes were worsening over time, the trend became flatter or began to improve slightly after 2010. For example, the rate of low birth weight increased by about 0.4% per decade before 2010 and by only about 0.1% per decade after 2010. These results suggest that Black/white infant health gaps were declining prior to 2010, but this trend changed after 2010, when racial infant health gaps stabilized, neither increasing nor decreasing.

Panels C and D show results predicting infant health by maternal marital status. Among births to unmarried mothers (Panel C), results suggest declining rates of low/very low birth weight and preterm birth before 2010, followed by rising rates after 2010. For example, unmarried mothers' risk of low birth weight declined by about 0.7% per decade before 2010, but increased by 1.1% per decade after 2010. Trends in most other infant health measures became flatter after 2010 among births to unmarried mothers. Among births to married mothers (Panel D), infant health was growing poorer over time on all measures before 2010. After 2010, trends became flatter or improved over time. For example, the rates of low birth weight and preterm birth to married mothers increased by 0.3% and 0.6% per decade, respectively, before 2010. After 2010, low birth weight remained stable for married mothers and the likelihood of preterm birth declined by 1.6% per decade. Thus, results suggest that infant health inequality by marital status was decreasing before 2010, but changed afterwards. Inequality in the likelihood of low birth weight increased after 2010 while inequality of most others infant health outcomes remained constant.

Examining results by maternal education (Panels E and F), we find a clear pattern of rising inequality of infant health after 2010. Among births to mothers with less than high school (Panel E), infant health was fairly stable before 2010, with a slight decrease in low birth weight but also in mean birth weight and gestational length. After 2010, rates of low and very low birth weight increased by 1.4% and 0.2% per decade, respectively, while trends in mean birth weight and gestational length became flat. In contrast, Panel F suggests improving infant health after 2010 among births to mothers with a college degree. For example, rates of very low birth weight and preterm birth were increasing slightly before 2010, but decreased by 0.1% and 1.7% per decade after 2010. Trends in low and mean birth weight became flatter after 2010 and mean gestational length improved slightly after 2010. Results by maternal education suggest declining inequality of infant health before 2010, followed by rising inequality after 2010.

Combining axes of advantage and disadvantage, Panels G and H show results when predicting infant health measures among births to economically advantaged or disadvantaged mothers. In Panel G, we find that infant health outcomes became significantly poorer over time among births to economically disadvantaged mothers after 2010. For example, although the rate of low birth weight among economically disadvantaged mothers was declining over time by about 1% per decade before 2010, it increased at a faster rate after 2010 (about 1.5% per decade). Similarly, mean birth weight was increasing slightly by about 7 g per decade before 2010, but changed direction and decreased at a faster rate after 2010 (about 27 g per decade).

In contrast, we find a significant improvement in infant health measures after 2010 among births to advantaged mothers (see Panel H). For example, the rate of low birth weight to economically advantaged mothers was increasing over time (by about three-tenths of a percent per decade), but decreased slightly after 2010 (by about one-tenth of a percent per decade). Coefficients consistently indicate a diverging pattern by SES when predicting infant health measures. That is, results indicate increasing inequality of infant health by maternal SES after 2010 when examining each measure of infant health.

To summarize results in Table 1, we find declining inequality of infant health by maternal race, marital status, education, and SES before 2010, consistent with previous evidence (Aizer & Currie, 2014). After 2010, however, we find that inequality stabilized and trends became flatter by maternal race and marital status. Inequality of infant health by maternal education and SES not only stopped declining but increased since 2010. Regression results are consistent with trends in inequality of low birth weight and preterm birth rates (Figs. 1-3). Fig. 4 shows that gaps in the likelihood of low birth weight and preterm birth declined before 2010 by maternal race, marital status, education, and SES. After 2010, gaps became flat by race and increased by marital status, education, and SES, with the steepest increase by education and SES.

Overall, results suggest stalled and even backward progress on equality of infant health. Adding the time trend since 2010 significantly improves model fit when predicting most infant health measures among

Table 1
Predicted infant health measures by SES category.

Panel A: Births to Black Mothers							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	% Low Birth Weight	% Very Low Birth Weight	% Preterm Birth	Mean Birth Weight	Mean Gestational Length	Std Dev Birth Weight	Std Dev Gestational Length
Year	−0.04**	−0.01**	−0.10**	−1.15**	−0.01**	−1.58**	−0.02**
	(0.01)	(0.00)	(0.01)	(0.33)	(0.00)	(0.16)	(0.00)
Years Since 2010	0.05+	−0.03**	−0.00	1.55	0.03**	0.55	0.02**
	(0.03)	(0.01)	(0.05)	(1.01)	(0.01)	(0.48)	(0.00)
Constant	95.18**	13.93**	225.59**	5437.98**	62.93**	3796.68**	48.01**
	(14.42)	(3.55)	(24.70)	(658.88)	(2.57)	(322.66)	(1.06)
Observations	30	30	30	30	30	30	30
R-squared	0.60	0.79	0.83	0.38	0.74	0.90	0.99
Δ AIC	−1.19	−13.34	2.00	0.23	−15.79	0.78	−40.11
Δ BIC	0.21	−11.94	3.40	1.63	−14.39	2.18	−38.71
Log Likelihood Ratio Test	+	**			**		**

Panel B: Births to White Mothers							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	% Low Birth Weight	% Very Low Birth Weight	% Preterm Birth	Mean Birth Weight	Mean Gestational Length	Std Dev Birth Weight	Std Dev Gestational Length
Year	0.04**	0.01**	0.09**	−4.35**	−0.03**	−0.91**	−0.01**
	(0.00)	(0.00)	(0.01)	(0.21)	(0.00)	(0.08)	(0.00)
Years Since 2010	−0.03**	−0.01**	−0.25**	5.19**	0.05**	1.16**	0.00
	(0.01)	(0.00)	(0.05)	(0.80)	(0.01)	(0.21)	(0.00)
Constant	−68.93**	−11.05**	−163.20**	12,098.51**	98.76**	2369.13**	15.08**
	(4.59)	(1.06)	(22.37)	(421.29)	(4.12)	(151.88)	(0.81)
Observations	30	30	30	30	30	30	30
R-squared	0.92	0.84	0.67	0.95	0.90	0.89	0.97
Δ AIC	−7.97	−25.05	−21.83	−23.73	−29.38	−14.30	−0.15
Δ BIC	−6.57	−23.64	−20.42	−22.33	−27.98	−12.89	1.26
Log Likelihood Ratio Test	**	**	**	**	**	**	

Panel C: Births to Unmarried Mothers							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	% Low Birth Weight	% Very Low Birth Weight	% Preterm Birth	Mean Birth Weight	Mean Gestational Length	Std Dev Birth Weight	Std Dev Gestational Length
Year	−0.07**	−0.02**	−0.08**	−0.21	−0.02**	−2.26**	−0.02**
	(0.01)	(0.00)	(0.01)	(0.38)	(0.00)	(0.06)	(0.00)
Years Since 2010	0.18**	0.02**	0.08	−2.18+	0.02**	3.25**	0.03**
	(0.03)	(0.00)	(0.06)	(1.07)	(0.01)	(0.21)	(0.00)
Constant	147.35**	33.55**	174.12**	3663.77**	71.79**	5117.10**	52.03**
	(17.35)	(2.73)	(26.18)	(751.74)	(2.49)	(115.25)	(2.70)
Observations	30	30	30	30	30	30	30
R-squared	0.79	0.91	0.66	0.32	0.88	0.99	0.96
Δ AIC	−28.26	−17.97	−1.03	−1.71	−8.94	−67.27	−32.78
Δ BIC	−26.86	−16.57	0.37	−0.31	−7.54	−65.87	−31.38
Log Likelihood Ratio Test	**	**	+	+	**	**	**

Panel D: Births to Married Mothers							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	% Low Birth Weight	% Very Low Birth Weight	% Preterm Birth	Mean Birth Weight	Mean Gestational Length	Std Dev Birth Weight	Std Dev Gestational Length
Year	0.03**	0.00**	0.06**	−3.98**	−0.03**	−0.99**	−0.01**
	(0.00)	(0.00)	(0.01)	(0.23)	(0.00)	(0.09)	(0.00)
Years Since 2010	−0.03*	−0.01**	−0.22**	4.69**	0.06**	1.06**	0.01**
	(0.01)	(0.00)	(0.06)	(0.85)	(0.01)	(0.23)	(0.00)
Constant	−53.09**	−7.75**	−113.58**	11,355.83**	95.62**	2530.11**	20.56**
	(4.82)	(1.36)	(22.58)	(458.32)	(4.29)	(171.54)	(0.74)
Observations	30	30	30	30	30	30	30
R-squared	0.85	0.60	0.50	0.93	0.88	0.88	0.97
Δ AIC	−5.31	−14.44	−16.21	−19.24	−29.47	−8.97	−20.73
Δ BIC	−3.91	−13.04	−14.81	−17.84	−28.07	−7.57	−19.33
Log Likelihood Ratio Test	**	**	**	**	**	**	**

Panel E: Births to Mothers with Less than a High School Degree

VARIABLES	(1) % Low Birth Weight	(2) % Very Low Birth Weight	(3) % Preterm Birth	(4) Mean Birth Weight	(5) Mean Gestational Length	(6) Std Dev Birth Weight	(7) Std Dev Gestational Length
Year	−0.02**	−0.00*	0.01	−1.82**	−0.02**	−1.48**	−0.02**
	(0.01)	(0.00)	(0.01)	(0.28)	(0.00)	(0.07)	(0.00)
Years Since 2010	0.16**	0.02**	0.05	−1.82*	0.02**	3.11**	0.02**
	(0.01)	(0.00)	(0.03)	(0.70)	(0.00)	(0.28)	(0.00)
Constant	40.66**	5.35*	−11.29	6910.77**	88.29**	3529.31**	33.35**
	(11.51)	(2.00)	(17.23)	(554.36)	(1.75)	(134.53)	(2.17)
Observations	30	30	30	30	30	30	30
R-squared	0.80	0.61	0.36	0.87	0.97	0.96	0.94
Δ AIC	−41.42	−24.21	−0.33	−2.38	−23.05	−61.57	−32.15
Δ BIC	−40.02	−22.81	1.07	−0.98	−21.65	−60.17	−30.75
Log Likelihood Ratio Test	**	**		*	**	**	**

Panel F: Births to Mothers with a College Degree

VARIABLES	(1) % Low Birth Weight	(2) % Very Low Birth Weight	(3) % Preterm Birth	(4) Mean Birth Weight	(5) Mean Gestational Length	(6) Std Dev Birth Weight	(7) Std Dev Gestational Length
Year	0.04**	0.00**	0.06**	−4.91**	−0.02**	−0.86**	−0.01**
	(0.00)	(0.00)	(0.01)	(0.24)	(0.00)	(0.09)	(0.00)
Years Since 2010	−0.04**	−0.01**	−0.23**	4.81**	0.05**	0.94**	0.00**
	(0.01)	(0.00)	(0.05)	(0.90)	(0.01)	(0.28)	(0.00)
Constant	−76.73**	−6.00**	−119.63**	13,249.00**	88.22**	2264.70**	14.24**
	(5.41)	(1.20)	(24.56)	(473.47)	(4.28)	(189.50)	(0.83)
Observations	30	30	30	30	30	30	30
R-squared	0.91	0.56	0.53	0.96	0.84	0.84	0.94
Δ AIC	−8.82	−11.39	−18.02	−19.96	−27.34	−6.31	−6.68
Δ BIC	−7.42	−9.99	−16.62	−18.56	−25.94	−4.91	−5.28
Log Likelihood Ratio Test	**	**	**	**	**	**	**

Panel G: Births to Economically Disadvantaged Mothers

VARIABLES	(1) % Low Birth Weight	(2) % Very Low Birth Weight	(3) % Preterm Birth	(4) Mean Birth Weight	(5) Mean Gestational Length	(6) Std Dev Birth Weight	(7) Std Dev Gestational Length
Year	−0.12**	−0.02**	−0.21**	0.67	−0.00+	−2.21**	−0.03**
	(0.01)	(0.00)	(0.02)	(0.45)	(0.00)	(0.09)	(0.00)
Years Since 2010	0.27**	0.02**	0.33**	−3.35*	−0.01	2.81**	0.04**
	(0.05)	(0.01)	(0.08)	(1.51)	(0.01)	(0.32)	(0.00)
Constant	263.47**	46.64**	428.85**	1721.97+	45.63**	5037.00**	62.79**
	(29.61)	(6.52)	(42.35)	(905.77)	(3.91)	(184.67)	(2.34)
Observations	30	30	30	30	30	30	30
R-squared	0.76	0.79	0.82	0.15	0.35	0.97	0.97
Δ AIC	−19.19	−4.48	−13.49	−2.85	1.23	−35.25	−43.13
Δ BIC	−17.79	−3.08	−12.09	−1.45	2.64	−33.85	−41.73
Log Likelihood Ratio Test	**	*	**	*		**	**

Panel H: Births to Economically Advantaged Mothers

VARIABLES	(1) % Low Birth Weight	(2) % Very Low Birth Weight	(3) % Preterm Birth	(4) Mean Birth Weight	(5) Mean Gestational Length	(6) Std Dev Birth Weight	(7) Std Dev Gestational Length
Year	0.03**	0.00**	0.07**	−4.33**	−0.03**	−0.89**	−0.01**
	(0.00)	(0.00)	(0.01)	(0.21)	(0.00)	(0.09)	(0.00)
Years Since 2010	−0.04**	−0.01**	−0.24**	5.21**	0.06**	0.88**	0.00**
	(0.01)	(0.00)	(0.05)	(0.85)	(0.01)	(0.26)	(0.00)
Constant	−55.62**	−3.56**	−127.33**	12,133.77**	89.61**	2295.51**	13.14**
	(5.10)	(0.89)	(25.57)	(422.99)	(4.70)	(176.29)	(0.73)
Observations	30	30	30	30	30	30	30
R-squared	0.85	0.46	0.53	0.95	0.82	0.85	0.93
Δ AIC	−12.49	−14.01	−17.30	−24.85	−26.95	−5.36	−7.89
Δ BIC	−11.08	−12.60	−15.90	−23.44	−25.55	−3.95	−6.49
Log Likelihood Ratio Test	**	**	**	**	**	**	**

NVSS birth data 1989–2018.
Regressions predict annual aggregate values based on a sample similar to that used by Aizer and Currie (2014): singleton live births to mothers ages 19–39.

Economically disadvantaged mothers are single, Black mothers with less than a high school degree.
Robust standard errors in parentheses.
**p < 0.01, *p < 0.05, + p < 0.1.
Change in AIC and BIC statistics indicate the difference in statistics for the full model compared to the model excluding years since 2010.
The log likelihood ratio test indicates whether adding years since 2010 significantly improves model fit.

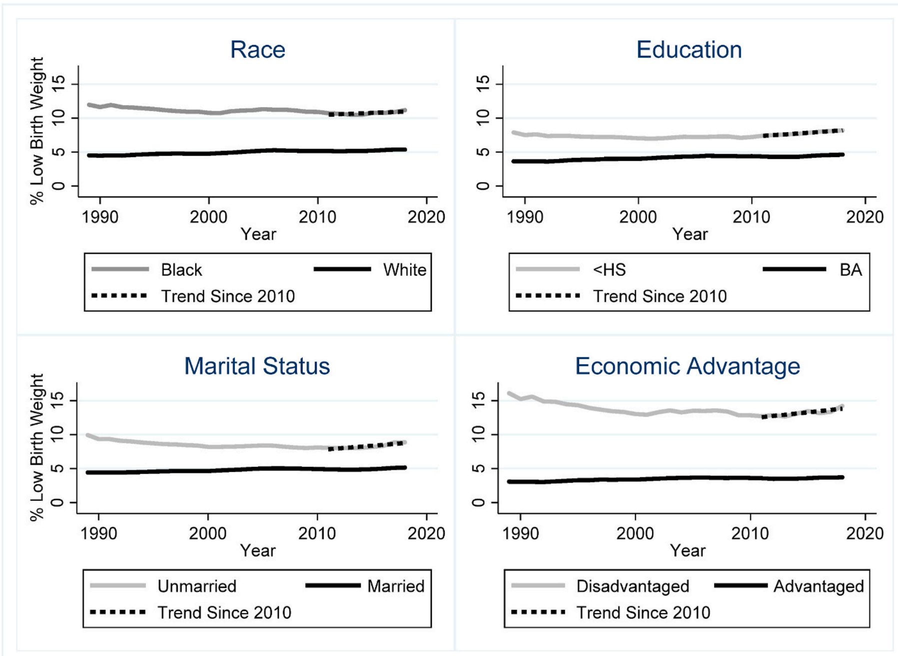

Fig. 1. Trends in Percent Low Birth Weight by Maternal Race, Education, Marital Status, and SES Category
NVSS birth data 1989– 18.
Economically disadvantaged category includes single, Black mothers with less than a high school degree. Economically advantaged category includes married, white mothers with a college degree.

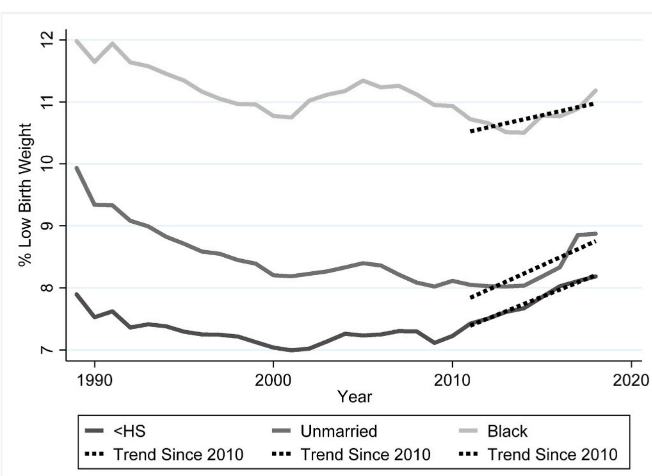

Fig. 2. Trends in Percent Low Birth Weight among Births to Mothers in Each Group Included in the SES Disadvantaged Category
NVSS birth data 1989–2018.

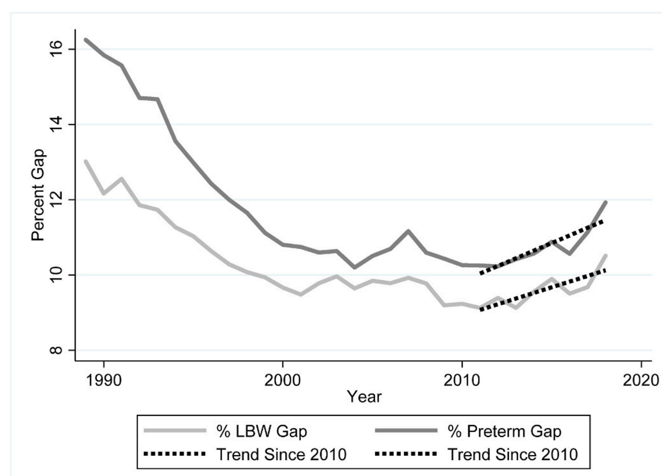

Fig. 3. Trends in Low Birth Weight and Preterm Gaps by Maternal SES Category: Disadvantaged Rate Minus Advantaged Rate
NVSS birth data 1989–2018.
Economically disadvantaged category includes single, Black mothers with less than a high school degree. Economically advantaged category includes married, white mothers with a college degree. Gap is the disadvantaged rate of low birth weight or preterm birth minus the advantaged rate.

most maternal categories, which suggests excluding the post-2010 trend would predict infant health more poorly. Adding the trend after 2010 better explains infant health and is worth the reduced parsimony of the model.

Results are consistent when accounting for a potential one-time shift in infant health after 2010 compared to earlier birth years (see Table S2). For example, adjusting for stable differences after 2010, predicted mean birth weight declined by 0.7 g per year among Black mothers, compared to a decline of 1.1 g among White mothers, which supports flatter racial inequality trends after 2010. Annual declines in predicted mean birth weight after 2010 are slightly larger among births to unmarried mothers and mothers with less than a high school degree (both −3.1 g per year), compared to married or college-educated mothers (−1.4 g and −2.7 g per year, respectively). Consistent with rising inequality, predicted mean birth weight among births to economically disadvantaged mothers declines by an average of about

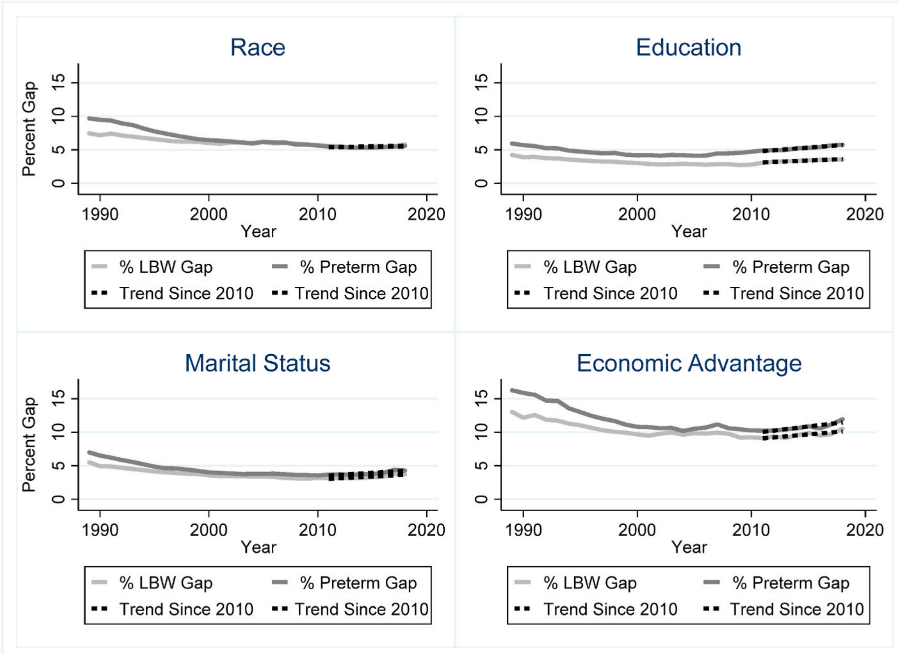

Fig. 4. Trends in Low Birth Weight and Preterm Gaps by Maternal Race, Education, Marital Status, and SES Category: Disadvantaged Rate Minus Advantaged Rate
NVSS birth data 1989–2018.
Economically disadvantaged category includes single, Black mothers with less than a high school degree. Economically advantaged category includes married, white mothers with a college degree.

3.4 g each year after 2010 when accounting for stable differences after 2010, while it decreases by about 1.6 g each year among economically advantaged mothers, suggestive of increasing inequality. Similarly, rates of low birth weight to economically disadvantaged mothers still increase by nearly a fifth of a percentage point on average each year after 2010 when adjusting for non-time-varying differences after 2010, but the trend does not significantly change after 2010 among economically advantaged mothers.

Results contradict *Hypothesis 1*, which predicted decreasing inequality in infant health after 2010. In addition, results are similar when excluding births to Hispanic mothers in both the economically disadvantaged and advantaged categories (see Appendix Tables S3-S4). This result contradicts *Hypothesis 2*, that trends could reflect rising births to Hispanic mothers, who tend to have healthier babies at lower socioeconomic levels.

Results support *Hypothesis 3*, which predicted that inequality of infant health increased after 2010. Figs. 1 and 2 illustrate this rising inequality since 2010: trends since 2010 are indicated by dashed lines. Results are similar when excluding states with inconsistent education information (Appendix Tables S5-S6).

Finally, estimates are consistent – though slightly attenuated among disadvantaged mothers – when controlling for aggregate economic measures (national poverty rate and the Gini coefficient of income inequality; Appendix Tables S7-S8). For example, the rate of low birth weight increased annually by 0.17% among economically disadvantaged mothers but decreased by 0.01% annually after 2010 ($p < 0.01$) when controlling for income inequality and poverty rates. Other infant health measures improved among advantaged mothers after 2010, while rates of very low birth weight and preterm birth increased among economically disadvantaged mothers. Results are consistent when controlling for an indicator for years after 2010. These results do not support *Hypothesis 4*, that controlling for aggregate economic inequality measures would account for increasing infant health inequality after 2010. Rather, our results suggest that holding constant aggregate economic inequality slightly attenuates the rising inequality of infant health. Thus, rising inequality may partially account for that trend. However, inequality of infant health increased after 2010, even when controlling for aggregate economic inequality measures.

Discussion

In this study, we examined trends in infant health inequality from 1989 to 2018, focusing on trends after 2010. Our analysis was motivated by competing claims of rising and narrowing inequality in earlier literature. We use annual vital statistics data for the population of U.S. births to consider how recent social policies (i.e., ACA passage), changing demographics, and economic inequality may have altered the relationship between infant health and socioeconomic status found in previous work. Our results reveal that infant health inequality increased since 2010 across a variety of health measures at birth.

Regression analyses predicting infant health separately by maternal race, marital status, and education suggest stalled progress toward equality by maternal race and marital status since 2010, while inequality increased most sharply by maternal education. Graphically examining trends in rates of low birth weight (see Fig. 1) reveals relatively stable and slightly increasing trends among married, white college-educated women since 1989. Rates of low birth weight declined before 2010 – narrowing inequality – among Black, unmarried mothers, with less than high school. After 2010, the declining trends reversed among these groups. Slight increases in rates of low birth weight among Black mothers matched the slight increase among white mothers, resulting in relatively stable inequality by race after 2010 (see Fig. 4). Likelihood of low birth weight increased more steeply after 2010 among unmarried mothers and particularly among mothers with less than high school – outpacing the trend among unmarried and college-educated women. The steepest increase in inequality of infant health is observed when combining all three of these axes of inequality, suggesting cumulative advantages or disadvantages based on maternal race, marital status, and education. Overall, results suggest progress toward equality of infant health stalled and even reversed after 2010.

The previous literature suggested that new and more knowledge about what matters for infant health and increased access to medical care would continue to close infant health gaps between economically advantaged and disadvantaged mothers. While it is difficult to test this prediction directly, our finding that infant health inequality grew suggests that new knowledge or access did not close infant health gaps. Instead, our evidence suggests that infant health inequality may increase rather than decrease if trends continue as they have over the past decade.

Our study is not without limitations. We would prefer to examine economic inequality directly, using information about maternal income or poverty status. However, individual income information is not available in the National Vital Statistics birth data. We also examine inequality in health among live births, which omits inequality of infant mortality. Future research could examine trends in inequality of infant health and mortality using alternative data with income. Furthermore, we examined potential explanations related to rising infant health inequality (e.g., economic inequality, increasing births to Hispanic mothers), but our data provide limited ability to identify the causes of this trend. To learn what is driving the increase in infant inequality, future research could consider how the population of single Black mothers without a high school diploma has changed over time. For example, we would expect the proportion of the population without a high school degree to decline as high school graduation rates increase and dropout rates decrease for all racial and ethnic groups (McFarland et al., 2019). This means that not completing high school today, relative to ten or twenty years ago, is a stronger indicator of one's social disadvantage, and may explain why the gap between economically advantaged and disadvantaged mothers has increased over time. Future research can directly examine why infant health disparities have changed over time between economically advantaged and disadvantaged mothers.

Moreover, not considered in our analysis is the extent to which infant health disparities are a result of racism. Phelan and Link (Phelan & Link, 2015) assert that racism is a fundamental cause of health inequalities. They suggest (p. 324) that the association between health and race in the U.S. results "from two fundamental associations: one between systemic racism and racial inequalities in SES and a second between SES and inequalities in health outcomes." We cannot test this model directly with our data and in future research it would be valuable to consider whether our proxy income measure (race, marital status, and educational attainment) is capturing systemic racism.

Despite limitations, our analyses use administrative birth data to provide more recent information about trends in inequality of infant health. Evidence of rising inequality since 2010 is cause for concern. Health at birth has implications for health, education, and earnings later in life (Black et al., 2007; Conley et al., 2003; Royer, 2009). Growing inequality at birth suggests that children face increasingly unequal life chances, necessitating interventions that target societal factors that put mothers and infants at risk for poor health, rather than intervening on individual-level factors (Phelan et al., 2010).

Ethics approval not required

This paper uses publicly available, secondary data and does not involve human subjects.

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Emily Rauscher: Conceptualization, Methodology, Software, Data curation, Formal analysis, Writing - original draft. **David E. Rangel:** Conceptualization, Writing - original draft.

Declaration of competing interest

The authors have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2020.100698.

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