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Associations between proximity to gas production activity in counties and birth outcomes across the US

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ABSTRACT

Despite mounting evidence on the health effects of natural gas development (NGD), including hydraulic fracturing ("fracking"), existing research has been constrained to high-producing states, limiting generalizability. To expand the scope of previous research, we examined the associations between prenatal exposure and NGD production activity in 28 states on birth outcomes overall and by race/ethnicity. We linked 2005–2018 county-level microdata natality files on 33,849,409 singleton births from 1984 counties in 28 states with nine-month county-level averages of NGD production by both conventional and unconventional production methods, based on month/year of birth. We estimated linear regression models for birth weight and gestational age and probit models for the dichotomous outcomes of low birth weight, preterm birth, and small-for-gestational age. We subsequently examined interactions between women's race/ethnicity and NGD production. We found that 53.8% of counties had NGD production activity. A 10% increase in NGD production in a county was associated with a decrease in mean birth weight by 1.48 g (95% CI = −2.60, −0.37), with reductions of 10.19 g (−13.56, −6.81) for infants born to Black women and 2.76 g (−5.05, −0.46) for infants born to Asian women. A 10% increase in NGD production in a county was associated with an increased risk of infants born low birth weight (0.0008; 95% CI = 0.0006, 0.0010) or small-for-gestational age (0.0018; 95% CI = 0.0015, 0.0022), particularly among infants born to Black women. In sum, NGD for energy production has negative impacts on the health of infants, with greatest effects in infants born to minoritized women.

1. Introduction

Since the introduction of hydraulic fracturing ("fracking") to the energy landscape, the fracking boom across the United States (US) has occurred with limited regulations (Black et al., 2021). Fracking, a technique used in unconventional natural gas development, creates fractures in rock formations by pumping in large quantities of fluids at high pressure (U.S. Environmental Protection Agency, 2022). As conventional natural gas production declined from 2005 to 2019, unconventional gas production, including fracking, increased by 275% and now accounts for 75% of the domestic natural gas supply (U.S. Department of Energy, 2021). In 2017, it was estimated that 17.6 million people in the contiguous US lived within one mile of at least one active conventional or unconventional gas and/or oil well (Czolowski et al., 2017). While fracking can lead to economic benefits, including domestic growth and affordable fuel (Hausman and Kellogg, 2015; U.S. Department of Energy, 2021), there is mounting evidence of its negative effects on health.

Fetuses are particularly vulnerable to hazardous environmental exposures (Landrigan et al., 2004) and research over the last decade has demonstrated adverse effects on infant health from proximity to natural gas development (NGD) sites, including both conventional and unconventional production methods. A 2020 review identified 12 studies conducted in single localities examining the impact of *in utero* exposure to NGD on infant health (Deziel et al., 2020). NGD exposure was generally quantified in these studies either by distance of residence from gas wells and/or volume of well production. Four of the seven studies focused on fetal growth found that exposure was associated with lower birth weight and/or a higher likelihood of being born low birth weight (LBW) or small-for-gestational age (SGA) (Deziel et al., 2020). Five of

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the seven studies that evaluated preterm delivery reported a significant increase in risk with NGD exposure (Deziel et al., 2020). More recent studies have found similar associations with lower birth weight (Apergis et al., 2019; Cushing et al., 2020; Tran et al., 2020, 2021; Willis et al., 2021), being born LBW (Apergis et al., 2019; Tran et al., 2020, 2021), preterm birth (Cushing et al., 2020; Gonzalez et al., 2020; Tran et al., 2021), and SGA (Tran et al., 2020, 2021). Other studies have found limited or mixed evidence of associations (Cushing et al., 2020; Erickson et al., 2021, Tran et al., 2020). Despite more disadvantaged and minoritized communities experiencing greater environmental burdens (Boyce et al., 2016), only a few studies have examined the effects of NGD exposure on disparities in birth outcomes by race/ethnicity or education. Some of these studies have found that infants born to Hispanic and Black women (Cushing et al., 2020; Gonzalez et al., 2020; Willis et al., 2021) or to women with lower educational attainment (Gonzalez et al., 2020; Hill, 2018; Willis et al., 2021) had greater reductions in birth weight and increased risk of LBW, preterm birth, and SGA with NGD exposure than their respective counterparts.

Despite growing evidence of the negative impacts of NGD on infant health, most research to date has been geographically constrained to high-producing states, such as Colorado, Pennsylvania, Texas, Oklahoma, and California, limiting their generalizability. To expand the scope and generalizability of research on the health impacts of NGD, we linked geocoded NGD sites across the US to county-level birth certificate data over a 14-year-period, and analyzed the associations between prenatal exposure to NGD production activity in 1984 counties from 28 states and birth outcomes overall and by race/ethnicity. As NGD production, including fracking, becomes more common across the US, it is critically important to understand the extent to which it impacts the health of our most vulnerable population—infants.

2. Methods

2.1. Study sample

We obtained 2005 through 2018 county-level microdata natality files from the National Center for Health Statistics (NCHS), which includes detailed information on all births registered in the 50 US states and Washington, DC (National Center for Health Statistics, 2020). We included data from both the 1989 and 2003 revisions of the birth certificate as the primary variables of interest were consistent across both versions (National Center for Health Statistics, 2019).

The analytic sample included 33,849,409 singleton live births with a gestational age of 30–44 weeks, whose birth weights were consistent for gestational age (Alexander et al., 1996), to women aged 16–49 years from the 28 states with any NGD activity over the study period. This repeated cross-sectional study was reviewed by the Boston College Institutional Review Board and considered it exempt.

2.2. Birth certificate demographic and health-related information

We included demographic and health-related information as reported on the mother's worksheet and facility worksheet of the birth certificate. On the mother's worksheet, women self-reported their race/ethnicity (white, Black, Hispanic, Asian, Other), education (0–11, 12, 13–15, ≥16 years), age (≤19, 20–24, 25–29, 30–34, ≥35 years), nativity (US born, foreign born), and marital status at the time of delivery (yes, no). We created a prenatal smoking indicator variable defined as whether women reported any smoking during pregnancy (1989 revision) or smoking during the first trimester (2003 revision) (yes, no). The facility worksheet recorded women's parity (1, 2, 3+), month of prenatal care initiation (none, 1st trimester, 2nd trimester, 3rd trimester), infant sex (male, female), and gestational age (weeks). We used NCHS-derived imputed data for missing values on women's race/ethnicity, age, marital status (2009–2016 only), infant sex, and gestational age (National Center for Health Statistics, 2019). All remaining missing values for education, nativity, marital status, parity, prenatal care initiation, and prenatal smoking were coded as such to be retained in the analyses.

2.3. Birth outcomes

From the facility worksheet, our dependent variables were continuous measures of birth weight (grams) and gestational age (weeks) as well as the following dichotomous outcomes: LBW (<2500 g versus ≥2500 g), preterm birth (<37 weeks versus ≥37 weeks), and SGA (<10th percentile versus ≥10th percentile for gestational age and sex) (Aris et al., 2019).

2.4. NGD production data

We acquired commercially-available monthly gas production data from Enverus (https://www.enverus.com/), formerly Drillinginfo, for every well in the US from 2004 through 2018. Data were geocoded by latitude/longitude and identified by county, parish, or borough. Monthly production data in million cubic feet (MCF) of natural gas, from conventional and unconventional production methods, were available for each geocoded well. In the dataset, it was not possible to differentiate conventional from unconventional production methods. We excluded wells with missing production data from the analyses, and wells with a latitude/longitude that did not match with the recorded state were reviewed by one of the authors and corrected.

In order to link NGD production to the county-level birth certificate data, we utilized geocoded measures of the county centroids (U.S. Census Bureau, 2021), which were computed by identifying the population-weighted central point in each county. The minimum distances between the county centroid and each well in that county were calculated using trigonometry. The county-level NGD production for a given month was weighted by location, using both inverse distance weighting and inverse distance squared weighting. Inverse distance weighting scales the production level by the inverse linear distance between the county centroid and well (i.e., production at a well 4 km from the centroid would be downweighted by 1/4, while a well twice as far away (8 km) would be downweighted by 1/8). The inverse distance squared measure allows for a nonlinear relationship between distance and weighting (i.e., the well 4 km from the centroid would have weight 1/16, while the well 8 km distant would have weight 1/64). The individual wells' weighted production was then summed at the county level. The county-month weighted production levels were averaged over the estimated month of conception and the 8 subsequent months to approximate an average gestation of 9 months. These nine-month county-level averages were merged with the birth certificate data based on month/year of birth. We also created an indicator of county-month weighted production levels averaged over the third trimester of pregnancy, i.e. 3 months prior to delivery.

2.5. Statistical analysis

We conducted a series of regression models to examine the associations between prenatal exposure to NGD production activity and birth outcomes. We used linear regression models for birth weight and gestational age and probit models for the dichotomous outcomes of LBW, preterm birth, and SGA. Models were adjusted for women's race/ethnicity, education, age, nativity, marital status, parity, prenatal care initiation, prenatal smoking, infant sex, and gestational age (except for outcomes of gestational age and preterm birth). All models were also adjusted for birth year as a continuous measure, with county random effects and clustering by county.

Recognizing that Black and Hispanic women are disproportionately impacted by prenatal exposure to NGD production (Cushing et al., 2020; Gonzalez et al., 2020; Willis et al., 2021), we subsequently included an interaction between NGD production activity and women's race/

ethnicity and tested interactions using Wald tests. We calculated semi-elasticities, changes in outcomes in response to percentage changes in exposures, among those births with *in utero* exposure to any NGD production activity in their county (N = 15,540,167) from average marginal effects. We examined the associations between a 10% increase in NGD production activity and each birth outcome overall and race/ethnicity-specific semi-elasticities derived from the fully interacted model. The final estimates were obtained from the following linear regression specification with birth weight (grams) as the outcome:

$$BW_i = \alpha + \beta_1 NGD_{i,c} + \beta_2 Cov_i + \beta_3 BYr + \eta_c + \epsilon_i$$

where *BW* is the infant's birth weight for mother *i*, $NGD_{i,c}$ is the weighted average measure of NGD production for mother *i* living in county *c* over the nine months of pregnancy, Cov_i is an indicator for the demographic and health-related covariates (women's race/ethnicity, education, age, nativity, marital status, parity, prenatal care initiation, prenatal smoking, infant sex, and gestational age (except for outcomes of gestational age and preterm birth)), *BYr* is the birth year (continuous), η_c is a county-level random effect, while ϵ_i is the idiosyncratic error. Models included clustered standard errors by county. A similar model was used for gestational age (weeks) and a probit regression for the dichotomous outcomes of LBW, preterm birth, and SGA.

We subsequently conducted two sensitivity analyses to test the robustness of the results across specifications. First, we repeated this series of analyses for NGD production activity in the third trimester of pregnancy. Second, we repeated the set of analyses from the main specification among the 14 states that increased NGD production over the study period.

We conducted analyses using Stata statistical software, version 17.0 (StataCorp, College Station, Texas), with robust SEs clustered at the county level.

3. Results

Across the 28 states, 53.8% (1067/1984) of counties had any NGD production activity over the study period (Table 1). While the number of counties with NGD production increased only slightly from 976 to 981 between 2005 and 2018, NGD production activity increased, on average, by 79%. Upon closer inspection, half of states decreased production by 35% and the other half of states increased production by 782%.

Overall, prenatal exposure to NGD production activity increased adverse birth outcomes. We found that a 10% increase in NGD production in a county was associated with a decrease in mean birth weight by 1.48 g (95% CI = −2.60, −0.37) (Table 2). An interaction by race/ethnicity ($p < 0.001$) revealed that a 10% increase in NGD production decreased birth weight for infants born to Black women by 10.19 g (95% CI = −13.56, −6.81) and Asian women by 2.76 g (95% CI = −5.05, −0.46), with no meaningful reductions in birth weight for infants born to women from other racial/ethnic groups. Although effect sizes were small, the results for the dichotomous outcomes were in the anticipated directions. A 10% increase in NGD production in a county was associated with an increased risk in infants born LBW (0.0008; 95% CI = 0.0006, 0.0010) or SGA (0.0018; 95% CI = 0.0015, 0.0022). Interactions (both $p < 0.001$) found higher risk for both outcomes among infants born to Black, Hispanic, and Asian women.

We found some evidence that a 10% increase in NGD production in a county was associated with an increase in gestational age by 0.01 weeks (95% CI = 0.00, 0.02), with a greater likelihood (interaction $p < 0.001$) among infants born to Black (0.01; 95% CI = 0.00, 0.02) and Hispanic (0.03; 95% CI = 0.01, 0.04) women (Table 2). As there are 168 h in a week, this result translates to, on average, less than a 2-hour increase in gestational age. We also found that a 10% increase in NGD production was associated with a reduction in the risk of preterm birth (−0.0008; 95% CI = −0.0012, −0.0005), particularly (interaction $p < 0.001$) among infants born to Hispanic women.

Table 1
Characteristics of the 28 states (1,984 counties) with NGD production from 2005 to 2018 (N = 33,849,409).

State	N	% counties (Total N) with any NGD from 2005 to 2018	% change in number of counties with NGD production from 2005 to 2018	% change in NGD production (in counties with NGD) from 2005 to 2018
Alaska	147,194	10.3 (29)	0.0	−9.9
Alabama	789,060	35.8 (67)	−14.3	−56.1
Arkansas	513,673	36.0 (75)	8.3	210.9
Arizona[a]	1,094,920	6.7 (15)	0.0	−77.1
California	6,784,248	53.4 (58)	−10.3	−31.5
Colorado	888,844	59.4 (64)	0.0	48.7
Kansas	526,476	86.7 (105)	0.0	−47.2
Kentucky[a]	723,409	60.0 (120)	6.9	−8.5
Louisiana	826,255	95.3 (64)	−1.7	120.0
Maryland[a]	843,435	8.7 (23)	0.0	−43.7
Michigan	1,536,254	75.9 (83)	7.3	−51.1
Missouri	1,012,676	6.1 (114)	25	79.3
Mississippi	530,341	53.7 (82)	−2.5	13.9
Montana	161,531	60.7 (56)	0.0	−14.2
North Dakota	131,141	32.1 (53)	0.0	1381.6
New Mexico	361,601	42.4 (33)	−8.3	−6.1
New York	3,181,520	37.1 (62)	−22.7	−78.6
Ohio	1,863,843	71.6 (88)	5.7	2995.4
Oklahoma	697,339	93.5 (77)	0.0	67.4
Oregon	611,068	2.8 (36)	0.0	4.2
Pennsylvania	1,877,120	53.7 (67)	12.9	3323.1
South Dakota	159,646	4.5 (66)	0.0	−44.4
Tennessee[a]	976,145	20.0 (95)	22.2	1909.5
Texas	5,187,985	91.6 (250)	−0.5	52.7
Utah	689,049	41.4 (29)	0.0	−5.6
Virginia	1,365,388	7.4 (95)	0.0	25.0
West Virginia	269,353	92.7 (55)	0.0	716.8
Wyoming	99,895	95.7 (23)	0.0	−9.8

NGD, natural gas development.
[a] NGD data available for Arizona through 01/2017, Kentucky through 12/2017, Maryland through 05/2016, and Tennessee through 12/2016. Statistics calculated based on available data.

In sensitivity analyses, we first showed that NGD production in the third trimester of pregnancy was highly correlated with production across pregnancy (correlation coefficient r = 0.969). Results were broadly similar to the main models, with some differences across racial/ethnic groups (Supplemental Table 1). Second, the results among the 14 states that increased NGD production over the study period were in line with those from the main specification and for some outcomes, such as birth weight, were larger in effect (Supplemental Table 2).

4. Discussion

We have shown that as NGD production, including fracking, has increased across the US, there have been negative, downstream effects on birth outcomes, with the greatest impacts among infants born to minoritized women. We found that increases in NGD production decreased mean birth weight and slightly increased gestational age, particularly for infants born to Black women. Half of the states increased their NGD production over the study period, ranging from a 4.2% increase in Oregon to a 3323.1% increase in Pennsylvania. According to our estimates, if Oregon's NGD production increased to 100%, the median increase, the birth weight of Black infants born to Oregon mothers would decrease, on average, by 101.9 g and gestational age would increase by 0.1 weeks (16.8 h). Using county-level birth certificate data across 28 states, our results extend the generalizability of previous studies, but the measurement of NGD production was less precise than

Table 2
Semi-elasticities (95% CIs) of the impact of prenatal exposure to a 10% increase in NGD production activity (averaged over 9 months) on birth outcomes overall and by women's race/ethnicity (2005–2018).

	Overall	Interaction	White	Black	Hispanic	Asian	Other
Birth weight[a,b] (grams)	−1.48 (−2.60, −0.37)		−0.26 (−1.58, 1.06)	−10.19 (−13.56, −6.81)	−0.65 (−1.62, 0.33)	−2.76 (−5.05, −0.46)	−2.81 (−8.06, 2.43)
p-value	0.009	<0.001	0.7	<0.001	0.2	0.02	0.3
Gestational age[a] (weeks)	0.01 (0.00, 0.02)		−0.00 (−0.01, 0.01)	0.01 (0.00, 0.02)	0.03 (0.01, 0.04)	0.01 (−0.00, 0.01)	0.01 (−0.02, 0.04)
p-value	0.03	<0.001	0.7	0.01	<0.001	0.06	0.4
Low birth weight[a,b] (yes/no)	0.0008 (0.0006, 0.0010)		0.0003 (0.0000, 0.0005)	0.0039 (0.0031, 0.0047)	0.0004 (0.0001, 0.0007)	0.0004 (−0.0002, 0.0011)	0.0008 (−0.0010, 0.0026)
p-value	<0.001	<0.001	0.06	<0.001	0.01	0.2	0.4
Small-for-gestational age[a,b] (yes/no)	0.0018 (0.0015, 0.0022)		0.0013 (0.0009, 0.0018)	0.0081 (0.0068, 0.0093)	0.0006 (0.0001, 0.0012)	0.0034 (0.0022, 0.0045)	−0.0008 (−0.0035, 0.0020)
p-value	<0.001	<0.001	<0.001	<0.001	0.02	<0.001	0.6
Preterm birth[a] (yes/no)	−0.0008 (−0.0012, −0.0005)		0.0001 (−0.0008, 0.0010)	−0.0004 (−0.0028, 0.0020)	−0.0023 (−0.0036, −0.0011)	0.0003 (−0.0007, 0.0012)	−0.0011 (−0.0042, 0.0019)
p-value	<0.001	0.001	0.9	0.8	<0.001	0.6	0.5

NGD, natural gas development.
[a] Model adjusted for women's race/ethnicity, education, age, nativity, marital status, parity, prenatal care initiation, prenatal smoking, infant sex, birth year; models included county random effects and clustering by county.
[b] Model also adjusted for gestational age.

prior research. Taken together, this suggests that our findings may potentially underestimate the true effects of *in utero* exposure to NGD production on birth outcomes.

Our results align with other studies that found associations between exposure to NGD production with decreased birth weight (Apergis et al., 2019; Cushing et al., 2020; Deziel et al., 2020; Tran et al., 2020, 2021; Willis et al., 2021), and increased risk of infants born LBW (Apergis et al., 2019; Deziel et al., 2020; Tran et al., 2020, 2021), or SGA (Deziel et al., 2020; Tran et al., 2020, 2021). However, in others, associations have been mixed (Cushing et al., 2020; Erickson et al., 2021). Our results were inconsistent with prior literature that has reported a positive association between exposure to NGD production and preterm birth (Cushing et al., 2020; Deziel et al., 2020; Gonzalez et al., 2020; Tran et al., 2021). We found a slight increase in gestational age (equivalent to <2 h) and decrease in infants being born preterm (0.0008 percentage points), which has minimal clinical significance. Additionally, the interaction between exposure to NGD production and race/ethnicity was similar to previous findings (Cushing et al., 2020; Gonzalez et al., 2020; Willis et al., 2021) showing a larger burden of adverse birth outcomes among infants born to women of color. It is also important to note that recent studies have demonstrated the detrimental effects of exposure to NGD production activity during pregnancy on maternal mental and physical health, although the findings are mixed on the mediation pathway (Aker et al., 2022; Casey et al., 2018; Willis et al., 2022).

There are multiple challenges in comparing this body of research related to methodological inconsistencies involving measurement of NGD production type, distance, and intensity of exposure. Similar to our approach, some studies have included both conventional and unconventional NGD (Apergis et al., 2019; Cushing et al., 2020; Deziel et al., 2020; Gonzalez et al., 2020; Tran et al., 2020; Willis et al., 2021), while others have focused on fracked wells (Erickson et al., 2021; Tran et al., 2021), or also included inactive wells (Tran et al., 2020). We considered a woman to be exposed if she lived in a county that contained any NGD production because county was the lowest geographical identifier available on the birth certificate. Others with more granular geographic information have classified exposure based on distance of wells (Cushing et al., 2020; Gonzalez et al., 2020; Tran et al., 2020, 2021), or bucketed distances (Apergis et al., 2019; Willis et al., 2021). Finally, the measured intensity of NGD exposure also varies. Studies, including ours, have used production volume (Erickson et al., 2021; Tran et al., 2020), while others have used well counts or well density (Apergis et al., 2019; Cushing et al., 2020; Erickson et al., 2021; Gonzalez et al., 2020; Tran et al., 2020), which does not capture volume. In sum, consistency in measurement is essential in order to synthesize findings and quantify the effects of NGD production on birth outcomes.

To our knowledge, this evaluation of the effects of prenatal exposure to NGD production on birth outcomes is the largest to date, with data on nearly 34 million births across 1984 counties from 28 states. While previous studies focused on individual, high-producing states (Apergis et al., 2019; Cushing et al., 2020; Deziel et al., 2020; Erickson et al., 2021; Gonzalez et al., 2020; Tran et al., 2020, 2021; Willis et al., 2021), examining exposure across all NGD-producing states enhances the generalizability of findings to infants across the US. Recognizing that minoritized communities suffer greater environmental injustices (Boyce et al., 2016), we examined racial/ethnic disparities in NGD exposure and found that infants born to women of color have worse health outcomes than infants born to white women. We did not find that minoritized women lived in counties with higher NGD production than white women either across the entire analytic sample ($p = 0.5$) or the subset of births with any NGD production activity in their county ($p = 0.8$). We also did not find that the racial/ethnic composition of the counties changed from 2005 to 2018, as the correlation of women who identify as white, Black, Hispanic, Asian, and Other ranged from $r = 0.953$ to 0.998. These results suggest that NGD exposure in addition to other environmental and social factors experienced by women of color may exacerbate existing health disparities.

4.1. Limitations

This study also had a number of limitations. First, as noted, county was the lowest geographic unit available and we used the population-weighted county centroid to calculate the distance from each well. While using this method is less precise for larger counties, we tried to control for this by taking into account population density rather than the geographic midpoint. Second, mobility is a concern across much of the existing research. As our exposure was calculated based on women's county of residence at delivery, we were unable to quantify the changes in exposure for women who moved counties during their pregnancy. Similarly, exposure misclassification may have occurred for mothers who live and work in different counties. However, studies have shown that that environmental exposure estimates based on address at birth versus address at conception are highly correlated, with less than a third of women moving during pregnancy, and when moving did occur, the distance was generally short (<10 km) (Bell et al., 2018; Bell and Belanger, 2012). Third, while conventional and unconventional methods are used for both oil and gas production, the current analysis focused on NGD activity to be comparable with prior research. As noted, consistency across studies related to definitions of exposures and similar methodology will enhance this body of research. Lastly, data were not available to separate conventional versus unconventional NGD production. However, as previously reported, NGD production via fracking currently accounts for 75% of the natural gas supply (U.S. Department of Energy, 2021) and both types of NGD produce pollutants (Czolowski et al., 2017), suggesting potentially deleterious health effects for either type of exposure.

5. Conclusions

Our findings contribute to the growing body of research demonstrating that NGD production has negative effects on infant health, particularly for those born to minoritized mothers. Most of the growth in NGD production since 2005 in the US has been attributed to fracking and production is projected to continue increasing (U.S. Energy Information Administration, 2022). While there are economic benefits, including job creation and energy independence (Hausman and Kellogg, 2015; U.S. Department of Energy, 2021), NGD production consumes fresh water, generates wastewater, requires diesel engines, and creates greater traffic volumes (Deziel et al., 2020). The consequences of NGD production also include effects on human health. Pollutants generated from NGD production infiltrate the air and water of surrounding communities (Mehany and Kumar, 2019), which can be ingested by pregnant women and cross the placenta, resulting in poor birth outcomes (Gonzalez et al., 2020). In recognition of the deleterious environmental and health effects specific to fracking, 7 states (Maryland, Vermont, Washington), including the basin states (Pennsylvania, New Jersey, Delaware, and New York), have banned fracking in certain regions or altogether (Phillips, 2021). While the benefits and costs of NGD production are important for policymakers to consider, it is critical that the effects on infant health are central to this discussion.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2022.102007.

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