Environmental Disaster, Pollution and Infant Health: Evidence from the Deepwater Horizon Oil Spill

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Abstract

In 2010, the Gulf Coast experienced the largest oil spill in U.S. history. Evaporation of crude oil chemicals can cause major health problems. This paper examines the impact of the Deepwater Horizon oil spill on air quality and infant health outcomes. Using U.S. Environmental Protection Agency (EPA) AirData, vital statistics data from National Center for Health Statistics (NCHS) and a difference-in-difference methodology, we find that the oil spill of 2010 decreases air quality (concentration of PM2.5, NO2, SO2 and CO) in affected coastal counties, increases incidence of low birth weight (<2500 grams) and incidence of premature born infants (<37 weeks of gestation). Heterogeneity effects reveal more pronounced adverse infant health outcomes for black, Hispanic, less educated, unmarried, and younger mothers. Results are robust to a wide range of controls and robustness checks.

JEL Classification: I12, J13, Q53
Keywords: Infant Health, Pollution, Oil spill.

1 Introduction

In 2010, the Gulf Coast experienced the largest oil spill in U.S. history. With an estimated release of about 5 million barrels of oil over nearly three months, the Deepwater Horizon Spill was almost 50 times larger than the second biggest spill in U.S. history, the 1969 Santa Barbara spill. The oil spill of 2010 in the Gulf Coast is an exogenous event that affected the coastal counties in the Gulf region. Coastal counties and parishes of Alabama, Florida, Louisiana, Mississippi and Texas have been negatively affected by the oil spill.

Recent research suggests that pregnant women, infants and children are at a higher risk of adverse health impacts due to pollution (e.g. Currie and Neidell (2005), Foster et al. (2009) and Janke (2014)). Using air quality data from the U.S. Environmental Protection Agency (EPA), infant health data from the National Center for Health Statistics (NCHS), and a difference-in-difference methodology, this study aims to investigate the causal impact of the oil spill on air quality (PM2.5, NO2, SO2 and CO) and on infant health outcomes (birth weight, low birth weight incidence, gestation in weeks and premature newborn incidence). We compare air quality from monitoring stations near coastal counties with air monitoring stations in other southern counties (our main control group) and compare infant health outcomes of mothers in coastal counties in the Gulf Coast after 2010 to other infants born during the same period in other southern counties who were not affected by the oil spill. The health outcomes considered in this paper have been documented as good measures of infant health and are an important predictor of outcomes during childhood and adulthood (e.g. Black et al., (2007) and Figlio et al., (2014)).

We find that the oil spill of 2010 decreases air quality (concentration of PM2.5, NO2, SO2 and CO). We also find that the oil spill increases incidence of low birth weight (<2500 grams), incidence of prematurely born infants (<37 weeks of gestation) and that the oil spill significantly decreases the gestation in weeks and birth weight in grams. We distinguish the impact for mothers already pregnant at the moment of the oil spill to mothers who subsequently became pregnant, and find similar impacts. Heterogeneity effects reveal more pronounced adverse infant health outcomes for mothers who are black, Hispanic, less educated, unmarried and younger. The results have important policy implications as certain mothers are more affected by the pollution shock. This suggests that certain mothers can successfully apply measures to mitigate negative impacts of pollution. Resources and information should be targeted toward pregnant women in the aftermath of an environmental disaster to help prevent poor infant heath outcomes. This is also important as the literature documents long term benefits of infant health outcomes (e.g. Black et al. (2007), Figlio et al. (2014), and Sanders (2012)). Our results are robust to a wide range of robustness checks, placebo estimations and controls, including the county's monthly average employment and wages.

The rest of the paper is organized as follows: Section 2 reviews the literature; Section 3 discusses the oil spill, data and descriptive analysis; Section 4 presents the methodology; Section 5 presents the results and Section 6 concludes.

2 Literature review

Our paper is related to recent papers that document the negative impacts of oil on pollution and health. By example, Lavaine and Neidell (2017) find that a temporary reduction in oil refineries due to a strike leads to a significant reduction in Sulfur dioxide (SO2) concentrations and increases in birth weight and gestational age of newborns. Currie and Walker (2011) and Knittel et al. (2016) find that traffic congestion leads to air pollution and decreases infant health outcomes (see also Beatty and Shimshack, 2011). More closely related, oil spills have been shown to pose threats to human health from inhalation or dermal contact with oil and dispersant chemicals, as well as threats via seafood safety (see Laffon et al. (2006); Solomon and Janssen (2010); Reddy et al. (2012); Rotkin-Ellman, Wong, Solomon (2012) and D'Andrea & Reddy (2014)).

Our paper also joins a growing body of literature that study the negative impacts of pollution on health outcomes.[1] Recent papers document the negative impact of pollution on infant health outcomes in the United States. Chay and Greenstone (2003) use variations in air pollution reductions across sites due to the recession of 1981-1982 and find that a one percent reduction

[1] The literature of pollution on health and economic outcomes is vast. Zivin and Neidell (2013) offer a good survey of the literature.

in air pollution leads to a 0.35 percent decline in infant mortality. Currie et al. (2013) find a negative impact for water contamination and Currie & Neidell (2005) for air quality on infant health outcomes (see also Currie & Schmieder (2009A) and Currie et al. (2009B)). Research in several countries also provides evidence of an adverse impact of pollution on infant health outcomes: in Mexico (Arceo-Gomez et al., (2012); Foster et al., (2009)), India (Greenstone and Hanna, (2011); Brainerd and Menon, (2012)) and the United Kingdom (Janke et al., (2009)). Other papers have shown the adverse impact of pollution on human health leads to avoidance activities to reduce negative impacts of pollution. Some optimizing individuals compensate for increases in pollution by reducing their exposure. Zivin et al. (2011), by example, find that following water contaminations there is an increase in bottled water sales (see also Moretti and Neidell, (2011) and Janke, (2014)).

Prenatal exposure to pollution has also been found to have long term impacts. Figlio et al. (2014) study the relationship between birth weight and cognitive development. They find that the effects of infant health on cognitive development are important and constant through the school career. They find that the effect is invariant to school quality and similar across different family backgrounds. They conclude that infant health outcomes are an important predictor of school outcomes. Black et al. (2007), using twin data from Norway, find that birth weight is an important predictor of both short-term and long-run outcomes. In particular, they find that low birth weight negatively affects educational attainment and earnings. Persico et al. (2016) and Aizer and Currie (2015) find that prenatal exposure to environmental toxins reduces later developmental outcomes of children by reducing test scores, increasing the likelihood of repeating a grade and getting suspended from school (see also, Almond et al. (2009), Sanders (2012) and Lavy et al. (2015)).

This paper's contribution is to study the impact of the largest oil spill in U.S. history, an exogenous shock to the coastal regions, on air quality and infant health outcomes. We can analyze the impact on mothers already pregnant during the oil spill and perform our analysis by trimesters. We also contribute to the literature by distinguishing the impact by characteristics of the mothers: race, education, marital status and age. Our results suggest that certain mothers can successfully apply measures to mitigate negative impacts of pollution.

3 Deepwater Horizon Oil Spill Description, Data Sources, and Descriptive Statistics

3.1 Deepwater Horizon Oil spill

The Deepwater Horizon oil spill (also called Gulf of Mexico oil spill or BP oil spill) is recognized as the worst oil spill in U.S. history and one of the worst environmental disasters of all time.[2] The Deepwater Horizon rig was situated in the Gulf of Mexico, approximately 40 miles off the coast of Louisiana. On April 20, 2010, a final cement seal on an oil well failed, causing an explosion. Of the 126 workers aboard the oil rig, 11 were killed. The rig sank on the morning of April 22, the pipe leaked and oil began to discharge into the Gulf. The well was capped on July 15, 2010, 87 days later. The U.S. government estimates than about 5 million barrels of oil were released into the Gulf of Mexico over that 87 day period.

By early June 2010, oil had washed up on Louisiana's coast and along the Mississippi, Florida, Texas and Alabama coastlines. Efforts were put in place shortly after the oil spill to control the spread of oil to beaches and other coastal ecosystems using floating booms to contain surface oil and chemical oil dispersants to break it down underwater. In December 2012, several miles of coastline remained subject to evaluation and/or cleanup operations. Figure 1 presents a map of affected coastal counties. We use the National Oceanic and Atmospheric Administrations (NOAA) List of Coastal Counties from the Bureau of the Census Statistical Abstract Series.[3] The oil spill, along with the response and cleanup activities, caused extensive damage to marine and wildlife habitats as well as fishing and tourism industries. In July 2015, British Petroleum (BP) agreed to pay nearly 19 billion dollars to settle liabilities related to the oil spill.

[2] For more details on the oil spill, see the National Commission on the BP Deepwater Horizon Oil Spill, (2011), Reddy et al. (2012), Bishop et al (2017), Michael et al. (2013) and On Scene Coordinator Report: Deepwater Horizon Oil Spill (2011).

[3] Coastal counties represent our treatment group. Narrow coastal counties is used as an alternative treatment group in Table A.1. A list of coastal counties and narrow coastal counties are presented in Figure 1.

3.2 Data sources and Descriptive statistics

We use pollution data from the U.S. Environmental Protection Agency (EPA) AirData.[4] We have information on monthly average concentrations for the following major pollutants: nitrogen dioxide (NO2), particulate matter (PM2.5), sulfur dioxide (SO2) and carbon monoxide (CO). Nitrogen dioxide (NO2) is 1-hour daily data (standard of NO2 in 1-hour) measured in .01 parts per million (ppm). Particulate matter (PM2.5) is 24-hour daily data (standard of PM2.5 24-hour 2006) measured in micrograms per cubic meter (g/m3). The mean emissions for NO2 and PM2.5 in our sample are 97.80 and 11.49, respectively. Sulfur dioxide (SO2) is 1-hour daily data (standard of SO2 1-hour 2010) measured in .01 parts per million (ppm). Carbon monoxide (CO) is 1-hour daily data (pollutant standard of CO 1-hour 1971) measured in parts per million (ppm). The mean emissions for SO2 and CO in our sample are 23.17 and 0.35, respectively. The pollutants are covered by the Clean Air Act and are targeted by the EPA for their negative impacts on health, the environment and on properties. Of those pollutants, particulates have the strongest impact on health and can lead to or exacerbate respiratory problems, especially for people with asthma (e.g. Gent et al., 2003). N02 and SO2 also contribute to the formation of particulates. We use monitoring stations near the oil spill as our treatment group and use the other monitoring stations in other southern counties as our control group.

The main dataset used in this paper is the National Vital Statistics data from National Center for Health Statistics (NCHS). Vital Statistics from NCHS provides birth data of all the births registered in the United States. We use data from 2006 to 2012. We have access to more than 28 million birth observations over the period and we have county identifiers.[5] Of those 28 million, more than 9 million are in southern states.[6] We use this dataset to investigate the impact of the oil spill on infant health outcomes including premature births (<37 weeks of gestation), low birth weight (<2500 grams), gestation in weeks and birth weight in grams. The mean gestation in our sample is 38.44 weeks and the mean birth weight is 3226.38 grams.

[4]See www.epa.gov/air/urbanair/ for more details. Similar data is used in Beland and Boucher, (2015).

[5]We made a request and were granted access to the restricted data from NCHS for this project. These restricted data give access to county identifiers.

[6]We consider the following list of U.S. states as southern states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia. We have investigated different control groups in our robustness checks (see the heterogeneity and robustness section).

The incidence of premature and low birth weight are 13.43% and 9.17%, respectively. This dataset also enables us to control for the age, education, race, marital status and other risk factors of the pregnancy including plurality, place of the birth, prenatal visits, sex of the infant and characteristics of fathers. We also use this dataset to investigate the impact of the oil spill by identifying characteristics of the mother. In Table 1, we present descriptive statistics for variables of interest, including characteristics of mothers and fathers over our sample of years (2006 to 2012) for our treatment and control groups. Table 1 shows that the two groups are similar, but our treatment group has a higher non-white population and slightly higher fraction of mothers with a college degree.

4 Methodology

We first estimate the impact of the Deepwater Horizon oil spill on air quality using a difference-in-difference strategy. We estimate the following:

$$\begin{aligned} Airpolluants_{ct} &= \beta_0 + \beta_1 OSC_{ct} + \beta_2 OSC_{ct} * AfterApril_{2010} \\ &+ \beta_3 AfterApril_{2010} + \beta_4 X_{ct} + \beta_M + \beta_Y + \beta_C + \gamma_t + \gamma_t^2 + \epsilon_{ct} \end{aligned} \tag{1}$$

$Airpolluants_{ct}$ measures the air quality for the air monitoring stations near county (parish) c at month-year t. We use information on average concentrations for four major pollutants: PM2.5, NO2, SO2 and C0. OSC_{ct} is a dummy variable that takes a value of one for being an oil spill-affected county (OSC) and zero otherwise. $AfterApril_{2010}$ is a variable indicating that the oil spill occurred at time t. It takes a value of one for the months and years after April 2010 (after the oil spill in the Gulf of Mexico) and takes a value of zero for the months and years prior to April 2010. We use data from 2006 to 2012 for our main regressions. $OSC_{ct} * AfterApril_{2010}$ is the interaction term identifying the treatment group for whether the county c is affected by the oil spill after April 2010. β_2 is the coefficient of interest which captures the impact of the oil spill on air quality in the nearest monitoring stations. Our comparison group is the other monitoring stations not affected by the oil spill in other southern counties.[7] β_M, β_Y,

[7]We consider the following list of U.S. states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi,

β_C represent month, year and county fixed effects respectively and γ_t and γ_t^2 are linear and quadratic time trends. Standard errors are clustered at the county level.

Similarly, we estimate the impact of the oil spill in the Gulf of Mexico on infant health outcomes. We estimate the following equation:

$$\begin{aligned} HealthOutcome_{ict} &= \beta_0 + \beta_1 OSC_{ict} + \beta_2 OSC_{ict} * AfterApril_{2010} \\ &+ \beta_3 AfterApril_{2010} + \beta_4 X_{ict} + \beta_M + \beta_Y + \beta_C + \gamma_t + \gamma_t^2 + \epsilon_{ict} \end{aligned} \tag{2}$$

$HealthOutcome_{ict}$ represents the outcome variable for infant i at county c and month-year t. We consider the following infant health outcomes: gestation in weeks, premature birth (<37 weeks of gestation), birth weight (in grams) and low birth weight (<2500 grams). OSC_{ict} is a dummy variable that takes a value of one if mother lives in an oil spill county (OSC) and zero otherwise. $AfterApril_{2010}$ and $OSC_{ict}*AfterApril_{2010}$ are defined as above. β_2 is the coefficient of interest which captures the impact of the oil spill on infant health outcomes. Our comparison group is the other infants born in the same period who were unaffected by the oil spill in other southern counties. X_{ict} is a vector of characteristics of mothers with information on race, age, marital status, education and risk factors of the pregnancy. β_M, β_Y and β_C represent month, year and county fixed effects respectively and γ_t and γ_t^2 are linear and quadratic time trends. Standard errors are clustered at the county level. The sample is limited to mothers between the ages of 20 to 45 years old. In the heterogeneity and robustness sections, we investigate whether results are robust to several different control groups (all U.S., all U.S. except California and New York and propensity score matching), robustness checks, placebo tests and present event study graphs. We also investigate whether results vary by mother characteristics and by trimesters for mothers already pregnant at the moment of the oil spill.

North Carolina, South Carolina, Tennessee, Texas and Virginia.

5 Results

5.1 Main Results

We first look at the impact of the oil spill on air pollution in coastal counties, using air monitoring stations. Table 2 presents results for specification (1) and outcomes of the majors pollutants PM2.5, NO2, SO2 and C0. Table 2 shows that the concentrations of PM2.5, NO2, SO2 and C0 increased significantly in monitoring stations close to the oil spill and therefore the air quality is significantly negatively affected.[8] Using the mean emission in our sample and calculating a percentage increase, also presented in Table 2, we find that emissions for PM2.5, NO2, SO2 and C0 increased by 11.63%, 5.40%, 10.62% and 9.75%, respectively.

We next investigate the impact of the oil spill on infant health outcomes. Table 3 shows the impact of the oil spill for several infant health outcomes. Column (1) of Table 3 investigates whether the oil spill has an impact on the incidence of having a premature baby. Column (2) investigates the impact of the oil spill on incidence of low birth weight (<2500 grams). Columns (3) and (4) study the impact of the oil spill on gestation (in weeks) and birth weight (in grams). Table 3 shows that the oil spill significantly increases the incidence of premature babies (by 0.9%) and the incidence of low birth weight babies (by 1.2%). We also find that the oil spill significantly decreases gestation and birth weight. In sum, Table 3 shows that the Deepwater Horizon Oil spill has significant negative impacts on infant health outcomes.

5.2 Heterogeneity & Robustness

We next investigate several heterogeneity and robustness checks. Table 4 presents heterogeneity estimates by individual characteristics of mothers including race (white, black and Hispanic), age groups (age is less than 25, age 26 to 35 and above 35), educational attainment (college graduate, some college and high school or less) and marital status (married or unmarried). Table 4 shows higher adverse infant health outcomes for black, Hispanic, less educated, unmarried and younger mothers. By example, Table 4 shows that the oil spill increases the incidence of premature babies for high school diploma or less (by 1.27%), black (by 1.52%) and Hispanic (by

[8] Alternatively, we used PM10 as measures of Particulates and found once again a significant increase after the oil spill. Results of the impact of the oil spill on lead and benzene were not statistically significant.

1.29%) mothers. Results are similar for the incidence of low birth weights, gestation and birth weights. This suggests important policy implications as certain mothers are more affected by the oil spill. Table 4 suggests that certain mothers can successfully apply measures to mitigate negative impacts of pollution.

Table 5 studies the impact of the oil spill separately for women already pregnant at the moment of the oil spill and women who became pregnant subsequently. Table 5 shows that both women already pregnant and women who subsequently became pregnant are affected. Infant health outcomes are affected for both groups and the difference is not statistically different.[9] Table 6 studies the impact of the oil spill on infant health outcomes by trimesters for women already pregnant at the moment of the oil spill, using interaction terms. It shows that the negative impacts of the oil spill are present in all three trimesters for women already pregnant.

We next implement placebo tests in Tables 7 and 8, which are generated by turning on the oil spill dummy in different years before the oil spill incident. This placebo intervention should have no significant impact on air quality and infant health outcomes. If there is a positive significant relationship, then there are correlations between the trend and the oil spill. Tables 7 and 8 show that placebo treatments do not produce a significant effect on air quality and infant health outcomes. We take this as further evidence that prior trends are not generating these results. This gives confidence in our main results of Tables 2 and 3. Figure 2, Panel A shows the event study graphs for the effect of the oil spill on incidence of premature (left) and low birth weight babies (right). It shows that the oil spill significantly increases the incidence of premature and low birth weight babies in coastal counties, without discernible prior trends. Figure 2, Panel B does a similar exercise for air quality for PM2.5 (left) and SO2 (right). It shows that the oil spill affects air quality negatively without any prior trends.[10]

Table A.1 in the appendix investigates different definitions of the treatment group. We define the treatment group in three alternative ways: narrow coastal counties (most exposed to the pollution effects of the oil spill), coastal counties and close counties or the whole the gulf states

[9]Table A.6 in the appendix investigates whether the oil spill affects the propensity to become a mother by characteristics. Table A.6 suggests that women in our sample did not alter their childbearing decision due to the oil spill.

[10]Graphs for other outcomes are qualitatively similar.

(to consider possible spillover). We find that in alternate definitions of the treatment group the oil spill significantly increases the incidence of premature babies, increases significantly the incidence of low birth weight babies and significantly decreases the gestation in weeks and birth weight in grams, but results are significantly stronger for narrower definitions of the treatment group.[11] Table A.2 investigates heterogeneity of the impact for the different coastal states separately using interaction terms (for Alabama, Florida, Louisiana, Mississippi and Texas). Table A.2 shows that infant health outcomes in coastal counties are affected in all states. Table A.3 presents results for several alternate control groups. Table A.3, Panel A investigates whether results are similar if we use all U.S. births as our control groups and Panel B presents results for all births but removes births in the states of New York and California from our control group - two big states less likely to be comparable to our treatment group. Table A.3, Panel C presents propensity score matching.[12] Table A.3 shows, once again, that the oil spill leads to a decrease in infant health outcomes.[13]

One final test is to investigate the impact of changes to the labor market due to the oil spill. Aldy (2014) finds that the local labor market is affected after the Deepwater Horizon oil spill with some counties/parishes positively affected and others negatively.[14] To account for changes in the labor market, we first add controls for employment and wage to our specification and re-estimate Table 3.[15] Table A.4 in the appendix shows that we find qualitatively similar impacts to Table 3. Table A.5 studies separately the impact of the oil spill on counties with positive and negative employment effects. We find an impact on infant health outcomes in both groups. Tables A.4 and A.5 provide suggestive evidence that the negative impact on infant health is operated through the effect on pollution.

[11] We use the NOAA List of Coastal Counties from the Bureau of the Census Statistical Abstract Series four our main results. However, it is possible that there is some spillover to neighboring counties or that counties closer to the coast are more affected. Table A.1 investigates how results vary to alternate definitions of the treatment group.

[12] Propensity score matching is done on mother characteristics: race, age, marital status and education, as well as the risk factors of the pregnancy.

[13] We have replicated all main tables using those alternative definition and results were qualitatively the same.

[14] Aldy (2014) finds that Louisiana coastal parishes, and oil-intensive parishes in particular, experienced a net increase in employment and wages. In contrast, he finds that Florida counties, especially those south of the Panhandle, experienced a decline in employment.

[15] We use labor data from monthly county/parish-level data (quarterly data for wages) from the Quarterly Census of Employment and Wages (QCEW), similarly to to Aldy (2014).

Overall, results are robust to alternative specifications and robustness checks. These numerous robustness checks provide confidence that the oil spill increased air pollution and had negative impacts on infant health outcomes.

6 Conclusion

This paper examines the impact of the oil spill of 2010 in the Gulf of Mexico on air pollution and health outcomes of newborns. Using air data from the EPA, Vital Statistics data from the National Center for Health Statistics (NCHS), and a difference-in-difference methodology, we find that the oil spill of 2010 decreases the air quality (concentration of SO2, NO2, CO and PM2.5) in coastal counties and has a significant negative impact on infant health outcomes. Particularly, we find that the oil spill increases the incidence of low birth weight (<2500 grams) and incidence of premature birth (<37 weeks of gestation). We also find that the oil spill significantly decreases the gestation in weeks and birth weight in grams of babies born in coastal counties after the oil spill. Heterogeneity effects reveal higher adverse infant health outcomes for black mothers, Hispanic mothers, less educated mothers, unmarried mothers and younger mothers. Results are robust to a wide range of controls and robustness checks.

According to Butler and Behrman, eds (2007), the economic burden associated with preterm birth in the United States is at least $51,600 per infant born preterm. Given that we find a 0.9% increase in incidence of premature birth, we can estimate the related economic cost of the oil spill to be above 350 million dollars.[16] The associated economic costs are important. The results have important policy implications as certain mothers are more affected by the pollution shock. Our results suggest that certain mothers can successfully apply measures to mitigate negative impacts of pollution. Resources and information should be targeted toward pregnant women in the aftermath of an environmental disaster to help prevent poor infant heath outcomes. This is also important as the literature documents long term benefits of infant health outcomes (e.g. Black et al. (2007), Figlio et al. (2014), and Sanders (2012)).

[16]We calculate the cost as: $51,600*0.93%*744,723 births in our treatment group over the period.

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Table 1: Summary Statistics

	Treatment Group		Control Group	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Mother characteristics				
Mother has college degree	0.2406	[0.4275]	0.1887	[0.3912]
Mother is white	0.4073	[0.4913]	0.4840	[0.4997]
Mother is black	0.1949	[0.3961]	0.2264	[0.4185]
Mother is Hispanic	0.3569	[0.4791]	0.2483	[0.4320]
Mother's age	26.9575	[6.0491]	26.8862	[6.0881]
Mother is less than 20 years old	0.1111	[0.3143]	0.1153	[0.3195]
Mother is 20 to 35 years old	0.7962	[0.4028]	0.7905	[0.4069]
Mother is over 35 years old	0.0927	[0.2900]	0.0941	[0.2919]
Risk factors of pregnancy				
Fewer than 4 prenatal visits	0.1236	[0.3397]	0.1141	[0.3179]
Mother is married	0.5247	[0.4994]	0.5684	[0.4952]
Infant is male	0.5111	[0.4999]	0.5112	[0.4999]
First in birth order	0.3866	[0.4870]	0.4013	[0.4902]
Second in birth order	0.3079	[0.4616]	0.3143	[0.4901]
Third in birth order	0.1744	[0.3794]	0.1675	[0.3734]
Fourth or higher in birth order	0.1279	[0.3340]	0.1095	[0.3122]
Multiple Births	0.0316	[0.1749]	0.0329	[0.1785]
Father characteristics				
Father is less than 20 years old	0.0379	[0.1911]	0.0354	[0.1784]
Father is white	0.3483	[0.4764]	0.4161	[0.4929]
Father is black	0.1478	[0.3549]	0.1599	[0.3665]
Father is Hispanic	0.3035	[0.4598]	0.2120	[0.4088]

Note: This table shows summary statistics (mean and standard deviation). Time period is 2006 to 2012. Observations for treatment group: 744,723; Observations for control group: 8,580,116

Source: National Center for Health Statistics (NCHS).

Table 2: Impact of the oil spill on air pollutants

	(1) PM2.5	(2) NO2	(3) SO2	(6) CO
Oil spill	1.3361**	5.2834***	2.4616***	0.0346**
	(0.6126)	(2.2689)	(1.2086)	(0.0159)
Mean in sample	11.4906	97.8022	23.1746	0.3548
% change	11.63%	5.40%	10.62%	9.75%

Note: This table shows the impact of the oil spill shock in April 20, 2010 on air pollutants. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. The percentage change is calculated by dividing the regression coefficient from the mean in sample. The results are based on 181 monitoring stations for PM10, 119 for No2, 140 for So2 and 97 for CO in the southern United States. Time period is 2006 to 2012. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: US EPA AirData

Table 3: Impact of the oil spill on infant health outcomes

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Oil Spill	0.0093***	0.0119***	-0.05825**	-11.9617***
	(0.0027)	(0.0013)	(0.0230)	(2.8201)

Note: This table shows the main results. Control variables consist of mother characteristics including mother's age, mother's education, mother's race, whether the mother is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, and whether the child is male as well as father's age group and father's race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).

Table 4: Heterogeneity effect of the oil spill on infant health outcomes for all women

	(1) all	(2) College degree	(3) Some college	(4) High School Or less	(5) Age over 35	(6) Age 26-35
Panel A						
Premature (<37 weeks)	0.0093*** (0.0027)	-0.0054 (0.0045)	0.0064** (0.0030)	0.0127** (0.0051)	0.0038 (0.0050)	0.0096*** (0.0029)
LBW (<2500 grams)	0.0119*** (0.0013)	0.0014 (0.0023)	0.0071*** (0.0019)	0.0146*** (0.0021)	0.0001 (0.0029)	0.0091*** (0.0015)
Gestation (weeks)	-0.05825** (0.0230)	0.0308 (0.0252)	-0.0109 (0.0272)	-0.1018** (0.0411)	-0.0151 (0.0377)	-0.0652** (0.0257)
BW (grams)	-11.9617*** (2.8201)	5.2682 (4.2641)	-6.1233 (5.3138)	-15.1934*** (4.4471)	-7.6156 (6.7031)	-13.9575*** (3.6423)

Panel B	(7) Age below 25	(8) White	(9) Black	(10) Hispanic	(11) Married	(12) Unmarried
premature (<37 weeks)	0.0098*** (0.0031)	0.0011 (0.0025)	0.0152*** (0.0039)	0.0129** (0.0058)	0.0047 (0.0031)	0.0137*** (0.0032)
LBW (<2500 grams)	0.0166*** (0.0019)	0.0001 (0.0015)	0.0186*** (0.0045)	0.0124*** (0.0022)	0.0029 (0.0011)	0.0175*** (0.0022)
Gestation (weeks)	-0.0593** (0.0237)	-0.0116 (0.0240)	-0.1088*** (0.0382)	-0.0862* (0.0469)	0.0021 (0.0222)	-0.0678** (0.0258)
BW (grams)	-9.9984*** (3.4388)	-4.7484 (3.5363)	-13.7707 (9.1526)	-11.1634* (5.8643)	-0.9417 (4.0551)	-15.4006*** (3.9455)

Note: This table shows subgroup analysis for the impact of the oil spill on infant health outcomes. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).

Table 5: Impact of the oil spill on infant health outcomes by pregnancy status at time of oil spill

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Oil spill * pregnant	0.0092***	0.0118***	-0.0587**	-11.9769***
	(0.0027)	(0.0014)	(0.0229)	(2.8388)
Oil spill * not pregnant	0.0119***	0.0128***	-0.0548*	-11.6121***
	(0.0034)	(0.0016)	(0.0305)	(3.8893)

Note: This table shows the results by pregnancy status at the moment of the oil spill, using interaction terms. Control variables consist of mother characteristics including mother's age, mother's education, mother's race, whether the mother is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, and whether the child is male, as well as father's age group and father's race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).

Table 6: The effect of the oils spill on infant health outcomes at different trimesters

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Oil spill * 3rd Trimester	0.0097**	0.0061***	-0.1022***	-2.1866
	(0.0044)	(0.0019)	(0.0354)	(5.2026)
Oil spill * 2nd Trimester	0.0067**	0.0078***	-0.0533*	-9.3547***
	(0.0033)	(0.0017)	(0.0302)	(3.2921)
Oil spill * 1st Trimester	0.0083***	0.0104***	-0.0601*	-6.4663*
	(0.0030)	(0.0018)	(0.0310)	(3.8919)

Note: This table shows the results for the impact of the oil spill on infant health outcomes for different trimesters for mothers' already pregnant, using interaction terms. Time spans have been limited to include women who have been exposed to the oil spill shock either at first, second, or third trimesters of pregnancy. Control variables consist of mother characteristics including the mother's age, education, race, whether she is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, and whether the child is male, as well as father's age group and father's race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).

Table 7: Placebo test for the impact of the oil spill on pollutants

	(1) PM2.5	(2) NO2	(3) SO2	(4) CO
Oil spill * April 2008	-0.6720	0.4059	0.3788	0.0218
	(0.4868)	(0.4310)	(0.2779)	(0.0192)
Oil spill * April 2009	-0.2342	0.1896	0.0259	0.0044
	(0.3504)	(0.3481)	(0.1647)	(0.0143)

Note: This table shows the results for the placebo effect of oil spill on April 2008, and April 2009 on air pollution. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: US EPA AirData

Table 8: Placebo test for the impact of the oil spill on infant health outcomes

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Oil spill * April 2008	0.0011	-0.0006	-0.0229	2.0949
	(0.0019)	(0.0010)	(0.0184)	(2.1820)
Oil spill * April 2009	-0.0014	-0.0003	-0.0052	-0.9561
	(0.0023)	(0.0008)	(0.0134)	(1.9724)

Note: This table shows the results for the placebo effect of oil spill on April 2008, and April 2009 on infant health outcomes. Control variables consist of mother characteristics including mother's age, education, race, whether she is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, whether the child is male, as well as father's age group and father's race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.
* $p < 0.10$, ** $p < 0.05$, *** $p < .01$
Source: National Center for Health Statistics (NCHS).

Figures

Figure 1

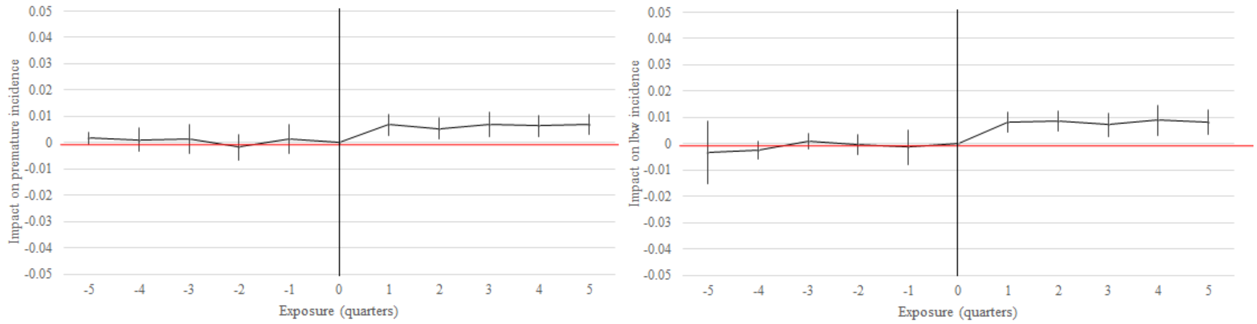
States	Counties/ Parishes
Florida	Bay*, Calhoun, Charlotte*, Citrus*, Collier*, De Soto, Dixie*, Escambia*, Franklin*, Gadsden, Gilchrist, Glades, Gulf*, Hardee, Hernando*, Hillsborough, Holmes, Jackson, Jefferson*, Lafayette, Lee*, Leon, Levy*, Liberty, Madison, Manatee*, Marion, Monroe*, Okaloosa*, Pasco*, Pinellas*, Polk, Santa Rosa*, Sarasota*, Sumter, Suwannee, Taylor*, Wakulla*, Walton*, Washington.
Alabama	Baldwin*, Clarke, Covington, Escambia, Geneva, Mobile*, Monroe, Washington.
Mississippi	Amite, George, Hancock, Harrison*, Jackson*, Lamar, Marion, Pearl River, Pike, Stone, Walthall, Wilkinson.
Louisiana	Acadia, Ascension, Assumption, Avoyelles, Beauregard, Calcasieu, Cameron*, East Baton Rouge, East Feliciana, Evangeline, Iberia*, Iberville, Jefferson*, Jefferson Davis, Lafayette*, Lafourche*, Livingston, Orleans, Plaquemines*, Pointe Coupee, Rapides, Sabine, St. Bernard, St. Charles, St. Helena, St. James, St. John the Baptist, St. Landry, St. Martin, St. Mary*, St. Tammany, Tangipahoa, Terrebonne*, Vermilion*, Vernon, Washington, West Baton Rouge, West Feliciana.
Texas	Aransas*, Austin, Bee, Brazoria*, Brooks, Calhoun*, Cameron*, Chambers*, Colorado, De Witt, Duval, Fayette, Fort Bend, Galveston*, Goliad, Harris, Hidalgo, Jackson, Jasper, Jefferson*, Jim Hogg, Jim Wells, Kenedy*, Kleberg*, Lavaca, Liberty, Live Oak, Matagorda*, Newton, Nueces*, Orange, Refugio, San Patricio*, Starr, Tyler, Victoria, Waller, Washington, Webb, Wharton, Willacy*.

Note: * Refers to narrow coastal counties and parishes.

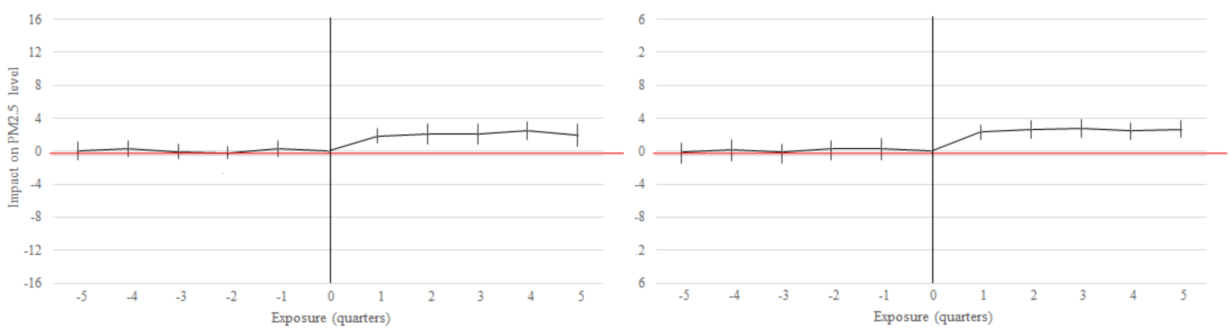
Source: National Oceanic and Atmospheric Administration's (NOAA) List of Coastal Counties for the Bureau of the Census Statistical Abstract Series.

Figure 2

Panel A



Panel B



Note: Figure 2 presents event study graphs. Figure 2, Panel A shows the event study graph for the effect of the oil spill on incidence of premature (left) for incidence of low birth weight babies (right). Figure 2, Panel B shows the event study graph for the effect for level of PM10 (left) and for level of SO2 (right). Exposure are defined as quarter before and after the oil spill.
Source: National Center for Health Statistics (NCHS) and US EPA AirData.

Appendix

Table A.1: Impact of oil spill on infant health outcomes for women using different treatment groups

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Narrow coastal counties	0.0141**	0.0134***	-0.0956**	-12.9756**
	(0.0057)	(0.0023)	(0.0476)	(5.7718)
Coastal counties (main results)	0.0093***	0.0119***	-0.0586**	-11.9617***
	(0.0027)	(0.0013)	(0.0230)	(2.8202)
Coastal counties + close counties	0.0047**	0.0073***	-0.0333*	-8.8188***
	(0.0023)	(0.0015)	(0.0173)	(2.7760)
Gulf states	0.0020	0.0044***	-0.0208	-6.1281**
	(0.0022)	(0.0012)	(0.0170)	(2.4802)

Note: This table shows the results for the impact of oil spill on infant health outcomes using different definition of the treatment group. Control variables consist of mother characteristics including mother's age, education, race, whether she is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, whether the child is male, as well as father's age group and race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).

Table A.2: The effect of the oil spill on infant health outcomes for different coastal counties (CC)

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Oil spill * CC of Alabama	0.0180***	0.0054***	-0.1232***	-5.3122
	(0.0069)	(0.0018)	(0.0172)	(4.1516)
Oil spill * CC of Florida	0.0023	0.0102***	-0.0120	-12.2364***
	(0.0024)	(0.0014)	(0.0463)	(3.7738)
Oil spill * CC of Louisiana	0.0105**	0.0151***	-0.0622***	-21.5556***
	(0.0051)	(0.0028)	(0.0224)	(5.1648)
Oil spill * CC of Mississippi	0.0042	0.0102***	-0.1501***	-18.0047
	(0.0028)	(0.0020)	(0.0137)	(11.9516)
Oil spill * CC of Texas	0.0119***	0.0121***	-0.2277*	-13.9498***
	(0.0042)	(0.0021)	(0.1170)	(4.0745)

Note: This table investigates potential heterogeneity of the effect by states, using interaction terms. Control variables consist of mother characteristics including mother's age, education, race, whether she is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, whether the child is male, as well as father's age group and race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.
* $p < 0.10$, ** $p < 0.05$, *** $p < .01$
Source: National Center for Health Statistics (NCHS).

Table A.3: Impact of the oil spill on infant health outcomes using different control groups

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Panel A– all U.S.				
Oil Spill	0.0115***	0.0122***	-0.0720***	-9.9543***
	(0.0024)	(0.0011)	(0.0208)	(2.3595)
Panel B – all U.S. excluding NY and CA				
Oil Spill	0.0104***	0.0121***	-0.0662***	-9.3446***
	(0.0024)	(0.0011)	(0.0208)	(2.3688)
Panel C – Propensity score matching				
Oil Spill	0.0155***	0.0142***	-0.1394***	-25.5442***
	(0.0012)	(0.0010)	(0.0090)	(2.0339)

Note: This table shows the main results for different control groups. Control variables consist of mother characteristics including mother's age, education, race, whether she is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, whether the child is male, as well as father's age group and race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. The time period is 2006 to 2012. The sample of Panel A is derived from 28,437,956 births in the U.S. over the period. Propensity score matching is done on mother characteristics: race, age, marital status and education, as well as the risk factors of the pregnancy. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).

Table A.4: Impact of the oil spill on infant health outcomes, controlling for labor market effects

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Oil Spill	0.0093**	0.0121***	-0.0513**	-12.0607***
	(0.0027)	(0.0015)	(0.0222)	(2.8560)

Note: This table replicates the main results by controlling for change in labor market in coastal counties due to the oil spill. To account for changes in the labor market, we add controls for average employment rate and wage by counties to our specification and re-estimate Table 3. Control variables consist of mother characteristics including mother's age, mother's education, mother's race, whether the mother is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, and whether the child is male as well as father's age group and father's race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS) and Quarterly Census of Employment and Wages (QCEW).

Table A.5: Impact of the oil spill on infant health outcomes by labor market impact

	(1) Premature (<37 weeks)	(2) LBW (<2500 grams)	(3) Gestation (weeks)	(4) BW (grams)
Panel A-				
Oil spill - Positive labor effect	0.0109**	0.0094***	-0.0584***	-7.7890*
	(0.0042)	(0.0031)	(0.0193)	(4.2878)
Panel B-				
Oil spill - Negative labor effect	0.0085***	0.0118***	-0.0511**	-10.6211***
	(0.0030)	(0.0014)	(0.0250)	(3.3694)

Note: This table shows the results by impact of the oil spill on the labor market (employment and wage). Control variables consist of mother characteristics including mother's age, mother's education, mother's race, whether the mother is married, and risk factors of the pregnancy including birth order, an indicator for whether it is a multiple birth, and whether the child is male, as well as father's age group and father's race. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS) and Quarterly Census of Employment and Wages (QCEW).

Table A.6: The effect of the oil spill on characteristics of mothers

		(1) College degree	(2) Some college	(3) High School Or less	(4) Age over 35	(5) Age 26-35
Panel A						
Propensity to become pregnant		0.0469 (0.0397)	0.0263 (0.0219)	0.0596 (0.0466)	0.0024 (0.0022)	0.0008 (0.0035)
Panel B						
	(6) Age below 25	(7) White	(8) Black	(9) Hispanic	(10) Married	(11) Unmarried
Propensity to become pregnant	-0.0031 (0.0032)	-0.0060 (0.0055)	0.0006 (0.0037)	0.0089 (0.0063)	-0.0046 (0.0049)	0.0046 (0.0049)

Note: This table shows the results for the effect of the oil spill on characteristics of new mothers. All the regressions include month, year and county fixed effects and state linear and quadratic time trends. Time period is 2006 to 2012 but for women not already pregnant at moment of oil spill. The sample is derived from 9,324,839 births in the southern United States over the period. Standard errors are clustered at the county level.

* $p < 0.10$, ** $p < 0.05$, *** $p < .01$

Source: National Center for Health Statistics (NCHS).