

1 CITY COUNCIL

2 CITY OF SANGER, CA

3 VINCENT WALL, JOSEPH VILLALOBOS, DONNA
4 BAILEY, EFREN RUBIO, MELISSA BEASELY, AND
5 HENRY PROVOST,

6 Appellants,

7 vs.

8 CITY OF SANGER PLANNING COMMISSION,

9 Appellee

ADDITIONAL EVIDENCE IN SUPPORT OF
APPELLANTS POSITION FOR PROPOSED
REQUIREMENT TO THE CONDITIONAL USE
PERMIT RESOLUTION 2018-07

10 The undersigned Appellant has attached several additional documents in support of the Proposed
11 Requirements to the Conditional Use Permit Resolution 2018-07. Each of these pieces of evidence together,
12 individually, and in combination with the previously presented evidence show that the proposed conditions create a
13 nexus between the increase of hours for the power plant, the increased emission from the power plant, and the
14 requested conditions. In order to avoid confusion the appendixes labeling will continue from the previous evidence
15 provided

16 Appendix F: Ha et al., “Associations Between Residential Proximity to Power Plants and Adverse
17 Birth Outcomes”, America Journal of Epidemiology, vol. 182, no. 3 (June 28, 2015) pages 215-224 (“Ha”). Ha
18 teaches that pregnant women living less than 5 Km (approximately 3.1 miles) from any power plant, including a
19 natural gas power plant, have an increase chance of having a preterm delivery, a very preterm delivery, and a low
20 birth weight (abstract). Ha describes these as adverse birth outcomes.

21 Appendix G: Centers for Disease Control and Prevention, “Preterm Birth”,
22 <https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pretermbirth.htm> (“CDC”). According to the CDC
23 effects of a preterm birth, or delivery, are that the child could have:

- 24 1) Breathing problems,
- 25 2) Feeding difficulties,
- 26 3) Cerebral palsy,
- 27 4) Developmental delay(s),
- 28 5) Vision problems, and

ADDITIONAL EVIDENCE IN SUPPORT OF APPELLANTS POSITION FOR PROPOSED REQUIREMENT
TO THE CONDITIONAL USE PERMIT RESOLUTION 2018-07 - 1

1 6) Hearing problems.

2 Therefore, Ha (appendix F) teaches us that women who are pregnant and live less than 3.1 miles
3 from a power plant (basically the whole City of Sanger) will give birth to children who have an increased change of
4 having) breathing problems, 2) feeding difficulties, 3) cerebral palsy, 4) developmental delay(s), 5) vision
5 problems, and 6) hearing problems. The proposed conditions are a means to reduce this chance for the youngest,
6 newborn, citizens of our city.

7 Appendix H: March of Dimes, “Premature Babies”,
8 <https://www.marchofdimes.org/complications/premature-babies.aspx>, (“March of Dimes”). This appendix is a direct
9 link from the CDC, appendix G. March of Dimes states the besides the six (6) issues identified by the CDC with
10 respect to preterm birth a child born also has an increased risk of:

- 11 1) Apnea,
- 12 2) Respiratory distress syndrome (RDS),
- 13 3) Intraventricular hemorrhage (IVH),
- 14 4) Patent ductus arteriosus (IVH),
- 15 5) Necrotizing enterocolitis (NEC),
- 16 6) Retinopathy of prematurity (ROP),
- 17 7) Jaundice,
- 18 8) Anemia, and
- 19 9) Bronchopulmonary dysplasia (BPD).

20 Taking Appendix A, E, F, G, and H together, we see that the current and future citizens of Sanger
21 are already being harmed by the power plant. However, increasing the operating hours of the power plant without
22 mitigating the pollution caused by the increasing hours will further exacerbate the negative health effects of the born
23 and unborn children in Sanger.

24 Therefore, in order to mitigate these negative health effects the below signed Appellant urges the
25 City Council to adopt the proposed conditions to the CUP. By adding green space and planting trees the city will
26 provide an area that cooling the city thereby reducing the need for citizens to turn on their A/C units. Which in turn
27 will reduce the need for electricity. Thus, reducing the need for power plants to run as often. Thereby, improving the

Appendix F



Original Contribution

Associations Between Residential Proximity to Power Plants and Adverse Birth Outcomes

Sandie Ha, Hui Hu, Jeffrey Roth, Haidong Kan, and Xiaohui Xu*

* Correspondence to Dr. Xiaohui Xu, Department of Epidemiology, College of Public Health and Health Professions and College of Medicine, University of Florida, 2004 Mowry Road, CTRB 4219, Gainesville, FL 32610 (e-mail: xhxu@phhp.ufl.edu).

Initially submitted October 11, 2014; accepted for publication February 6, 2015.

Few studies have assessed the associations between residential proximity to power plants and adverse birth outcomes including preterm delivery (PTD), very preterm delivery (VPTD), and term low birth weight (LBW). We geocoded 423,719 singleton Florida births born from 2004 to 2005 and all active power plants and determined residential proximity to the nearest power plant for each birth. Prenatal exposure to particulate matter less than 2.5 μm in diameter for women living near different types of power plants was also determined by using National Environmental Public Health Tracking Network data. Logistic regression models were used to test the hypothesized associations. Women who lived closer to coal and solid waste power plants were exposed to higher levels of particulate matter less than 2.5 μm in diameter compared with other types. We observed a 1.8% (95% confidence interval (CI): 1.3, 2.3) increased odds for PTD, 2.2% (95% CI: 1.0, 3.4) for VPTD, and 1.1% (95% CI: 0.2, 2.0) for term LBW for each 5 km closer to any power plant. When stratifying by different fuel type, we found that only solid waste had an association with term LBW, whereas oil, gas, and solid waste all had an association with PTD and VPTD. Results were consistent when exposure was categorized by number of power plants. Our study found evidence of increasing odds of adverse birth outcomes among infants born to pregnant women living closer to power plants. More research is warranted to better understand the causal relationship.

birth outcomes; environment; low birth weight; pollution; power plants; preterm delivery

Abbreviations: CI, confidence interval; LBW, low birth weight; OR, odds ratio; $\text{PM}_{2.5}$, particulate matter less than 2.5 μm in diameter; PTD, preterm delivery; SD, standard deviation; VPTD, very preterm delivery.

Air pollution has been extensively linked to many negative health outcomes ranging from cardiorespiratory diseases (1–3) to hospitalizations (4–6) and mortality (7, 8). A recent risk analysis estimated that particulate matter less than 2.5 μm in diameter ($\text{PM}_{2.5}$) and ozone, estimated from the 2005 air quality level, were responsible for 130,000 and 4,700 excess deaths, respectively (9). These mortality estimates were significantly higher for the older population. In populous cities, the percentage of deaths attributable to $\text{PM}_{2.5}$ and ozone ranges from 3.5% in San Jose to 10% in Los Angeles (both in California) (9). Exposure to various air pollutants has also been linked to adverse pregnancy-related and birth outcomes including gestational hypertension, premature delivery, and low birth weight (10–13).

The American Lung Association has estimated that pollution specifically from power plants is responsible for approximately

13,000 excess deaths annually in the United States (14). Because living near power plants may expose people to additional sources of air pollution, this proximity may increase their risk of having negative health endpoints. According to the US Environmental Protection Agency, power plants release toxic chemicals into the air including mercury, heavy metals, and acid gases, all of which are known to be deleterious to human health, especially that of the unborn fetus (15). Moreover, there is recent evidence suggesting that harmful emissions from power plants may be increasing (16).

Because of accumulating evidence of a negative relationship between power plants and human health, a few studies have assessed the association between proximity to nuclear power plants and adverse birth outcomes, but no association was found (17–19). To our knowledge, few existing studies

Table 1. Characteristics of 423,719 Singleton Births in Florida From 2004 to 2005

Characteristic	Term LBW			PTD			VPTD			Controls		
	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%
Total participants		9,320	2.4		33,402	8.2		5,680	1.5		375,317	
Distance from plant, km												
Continuous	14.5 (11.8)			14.4 (11.6)			14.1 (11.5)			15.0 (12.1)		
Categorical												
<5		1,497	16.1		5,288	15.8		943	16.6		56,016	14.9
5–9.9		2,441	26.2		8,900	26.7		1,531	27.0		97,167	25.9
10–19.9		3,393	36.4		12,400	37.1		2,080	36.6		138,917	37.0
≥20		1,989	21.3		6,814	20.4		1,126	19.8		83,217	22.2
Maternal age, years	26.7 (7.1)			27.6 (6.9)			27.4 (7.3)			27.5 (6.4)		
Gestational age, weeks	38.0 (1.0)			35.1 (1.2)			27.9 (2.6)			39.0 (1.1)		
Mother's education												
Less than high school		2,560	27.8		7,730	23.4		1,397	25.2		77,011	20.7
High school/some college		4,749	51.6		16,674	50.5		2,942	53.1		183,225	49.3
College degree		1,504	16.4		6,896	20.9		984	17.8		88,270	23.7
Graduate school		394	4.3		1,710	5.2		215	3.9		23,343	6.3
Maternal race												
White		3,344	36.4		14,615	44.1		1,864	33.3		176,354	47.4
Black		2,756	30.0		7,710	23.3		1,932	34.5		62,419	16.8
Hispanic		1,881	20.5		6,451	19.5		1,155	20.6		83,470	22.4
Asian/Pacific Islander		324	3.5		902	2.7		124	2.2		10,605	2.9
Others		894	9.6		3,430	10.4		522	9.3		39,483	10.6
Census block group annual income, US dollars												
<29,643.00 (first quartile)		3,026	32.5		9,174	27.5		1,892	33.3		92,338	24.6
29,643.00 to <38,095.00 (second quartile)		2,401	25.8		8,287	24.8		1,461	25.7		94,213	25.1
38,095.00 to <49,457.00 (third quartile)		2,152	23.1		8,288	24.8		1,320	23.2		94,303	25.1
≥49,457.00 (fourth quartile)		1,741	18.7		7,653	22.9		1,007	17.7		94,463	25.2

Table continues

have evaluated the association between residential proximity to different types of power plants and adverse birth outcomes (20). Furthermore, although power plant emissions are 1 of the major point sources of air pollution (21), which has been shown to have consistent association with adverse birth outcomes (22), there is limited information on air pollution exposure and pregnant women living close to specific types of power plants. Such information would be valuable in public health efforts to reduce adverse birth outcomes. Given that $PM_{2.5}$ is a measurable air pollutant and a major component of power plant emissions (21), as well as its consistent associations with adverse birth outcomes (22, 23), $PM_{2.5}$ can serve as a good indicator for air pollution from power plants. Florida has relatively high power plant emissions (16, 24) that provide a unique opportunity to investigate the potential association between power plant emissions and adverse birth outcomes. Thus, the primary purpose of this retrospective cohort study is to estimate the association between residential proximity to power plants and risk of adverse birth outcomes including term low birth

weight (LBW), preterm delivery (PTD), and very preterm delivery (VPTD) among singleton births in Florida from 2004 to 2005. We further stratify these associations by fuel type. Second, we use $PM_{2.5}$ as a surrogate for "pollution" from power plants to determine 1) the level of "pollution" exposure during pregnancy for women living close to power plants and 2) whether the amount of pollution depends on fuel type.

METHODS

Setting and participants

The source population was all livebirths recorded by the Florida Department of Health, Office of Vital Statistics (Florida Vital Records), from January 1, 2004, through December 31, 2005 ($n = 445,028$). After exclusion of births that had addresses outside Florida ($n = 4,672$); births that were missing address ($n = 423$), unable to geocode (e.g., only post office box available, $n = 563$), missing gestational age ($n = 937$),

Table 1. Continued

Characteristic	Term LBW			PTD			VPTD			Controls		
	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%
Urban neighborhood		8,160	87.6		28,972	86.7		4,986	87.8		323,992	86.3
Infant's sex, female		5,578	59.9		15,910	47.6		2,655	46.7		182,823	48.7
Marital status, married		4,408	47.4		18,549	55.6		2,631	46.4		224,450	59.8
Prenatal care, yes		9,055	97.2		32,214	96.4		5,224	92.0		370,271	98.7
Tobacco use												
Yes, <10/day		1,519	16.3		4,960	14.9		1,031	18.2		51,941	13.8
Yes, ≥10/day		1,128	12.1		2,586	7.5		472	8.3		22,611	6.0
Quit		190	2.0		548	1.7		99	1.7		5,952	1.6
No		6,483	69.6		25,308	75.8		4,078	71.8		294,813	78.6
Alcohol, yes		69	0.7		160	0.5		32	0.6		1,180	0.3
Season of conception												
Warm (May–October)		4,382	47.0		16,221	48.6		2,743	48.3		182,090	48.5
Cold (November–April)		4,938	53.0		17,181	51.4		2,937	51.7		193,227	51.5
Year of conception												
2003		3,243	34.8		10,772	32.3		1,448	25.5		135,717	36.2
2004		4,664	50.0		16,924	50.7		2,866	50.5		189,748	50.6
2005		1,413	15.2		5,706	17.1		1,366	24.1		49,852	13.3
Type of nearest power plant												
Coal		634	6.8		2,555	7.7		403	7.1		27,160	7.2
Gas		4,024	43.2		14,447	43.3		2,416	42.5		164,909	43.9
Nuclear		63	0.7		222	0.7		37	0.7		2,913	0.8
Oil		1,611	17.3		5,519	16.5		1,032	18.2		62,212	16.6
Solid waste		2,818	30.2		10,148	30.4		1,718	30.3		112,135	29.9
Other		170	1.8		511	1.5		74	1.3		5,988	1.6

Abbreviations: LBW, low birth weight; PTD, preterm delivery; SD, standard deviation; VPTD, very preterm delivery.

and multiple births ($n = 13,686$); and those with birth weight out of range (i.e., <500 and >5,000 g) ($n = 903$) and those with gestational age out of range (i.e., <140 days and >320 days) ($n = 125$), 423,719 births remained for analyses.

Exposure assessment

The exposure for this study was proximity to a nonrenewable-source power plant. All active power plants during the study period and eligible births were geocoded and mapped using ArcGIS V10.1 (ESRI, Redlands, California). Distance from the nearest power plants was measured in kilometers. The type of nearest power plant was also identified by fuel type. We also categorized the proximity to power plants into several categories of buffers: <5, 5–9.9, 10–19.9, and ≥20 km. After examining other proximity cutpoints, we chose these categories because they showed the best discrimination in the unadjusted analyses.

To describe prenatal exposures to $PM_{2.5}$, we estimated average daily residential exposures to $PM_{2.5}$ during pregnancy for each birth using data from the Centers for Disease Control and Prevention's National Environmental Public Health Tracking Network. These data are based on the US Environmental Protection Agency's Hierarchical Bayesian Prediction Model

output (25). Briefly, this model uses hierarchical Bayesian methods to combine data from observed air quality data measured at air monitors, the National Emission Inventory, and meteorological and photochemical data to produce 12×12 km gridded estimates of daily average $PM_{2.5}$ concentrations. We overlaid geocoded residential addresses over the 12×12 km grids. Prenatal exposure was assigned to each birth as the average daily $PM_{2.5}$ concentration over the first trimester for the grid in which it falls. We chose first trimester because 1) first trimester exposure to $PM_{2.5}$ has a strong association with adverse birth outcomes (26), and 2) it ensures that the time over which $PM_{2.5}$ is averaged is similar for cases and controls. The first trimester was defined as the first 13 weeks of gestation. A detailed description of this method was reported elsewhere (23). In addition, we also overlaid geocoded active power plants and the 12×12 km grids to determine the daily $PM_{2.5}$ concentrations near the power plants during the study period.

Outcome assessment

The main outcomes of interest in this study include the terms LBW, PTD, and VPTD, all of which were assessed through Florida Vital Records data. The term LBW was defined as a birth weighing less than 2,500 g at birth and born at

or after 37 weeks of gestation. PTD was defined as a birth that occurred before 37 but at or after 32 weeks of gestation. VPTD was defined as a birth that occurred before 32 weeks of gestation. On Florida birth certificates, the gestational age in weeks is typically determined by ultrasound measurements. When ultrasound is not available, fundal height (determined by clinical examination) or menstrual history is used to estimate gestational age. For controls, we used eligible births that had none of the 3 outcomes we assessed.

Covariates

Covariates were chosen on the basis of a directed acyclic graph (Web Figure 1 available at <http://aje.oxfordjournals.org/>). They included mother's age (continuous), maternal education (less than high school, high school graduate and/or some college, college graduate, graduate school), maternal race (white, black, Hispanic, Asian/Pacific Islander, and others), and marital status (married, unmarried). We also used Census 2000 data to determine census block group income as a proxy for neighborhood socioeconomic status and urbanity.

Statistical analyses

To describe exposures to PM_{2.5} during pregnancy and throughout the study period according to nearest power plants, we used scatterplots with locally weighted scatterplot smoothing (LOESS) functions (smooth = 0.5) to display averaged daily concentrations during the first trimester (*y*-axis) by date of delivery (*x*-axis), as well as daily concentrations (*y*-axis) by date during the study period (*x*-axis). We stratified the plots by fuel type for comparison. To compare continuous and categorical characteristics for participants with and without the 3 adverse birth outcomes, we performed *t* tests and χ^2 tests. We used logistic regression models to investigate the association between proximity to a power plant and the adverse birth outcomes. Two logistic regression models were used for each outcome: The first model was unadjusted, and the second model was a parsimonious model adjusted for potential confounders on the basis of our directed acyclic graph (Web Figure 1). We obtained the odds ratios and 95% confidence intervals for the increase in odds of having adverse birth outcomes for each 5 km closer to any power plant. We also compared the odds for different buffer sizes of <5, 5–9.9, 10–19.9, and ≥ 20 km from a power plant. We further stratified analyses for different types of plants. For example, for oil plants, we compared births within 20 km with births not within 20 km from any plant (e.g., excluding those who were closer to any other types of plant). We were unable to perform analyses for more refined proximity categories because of low sample size for certain cells. Data analyses were performed by using SAS, version 9.3, software (SAS Institute, Inc., Cary, North Carolina).

RESULTS

Table 1 shows participants' characteristics by term LBW, PTD, and VPTD. The sample prevalence was 2.4% for term LBW, 8.2% for PTD, and 1.5% for VPTD. Overall, the

Table 2. Association Between Proximity to Power Plants and Adverse Birth Outcomes in Florida From 2004 to 2005

Distance From Power Plant, km	Term LBW			PTD			VPTD			
	OR	95% CI	aOR ^a	OR	95% CI	aOR ^a	OR	95% CI	aOR ^a	95% CI
Continuous (for each 5 km closer)	1.018	1.009, 1.027	1.011	1.002, 1.020	1.020	1.015, 1.025	1.018	1.013, 1.023	1.031	1.019, 1.043
Categorical										
<5	1.118	1.045, 1.197	1.038	0.968, 1.113	1.153	1.110, 1.197	1.126	1.084, 1.170	1.244	1.140, 1.357
5–9.9	1.051	0.990, 1.116	1.026	0.965, 1.092	1.119	1.082, 1.156	1.114	1.077, 1.152	1.164	1.078, 1.258
10–19.9	1.022	0.966, 1.081	1.059	1.000, 1.121	1.090	1.057, 1.124	1.106	1.072, 1.141	1.107	1.029, 1.190
≥ 20	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; LBW, low birth weight; OR, odds ratio; PTD, preterm delivery; VPTD, very preterm delivery.
^a Adjusted for maternal age, education, marital status, census block group income, and urban neighborhood.

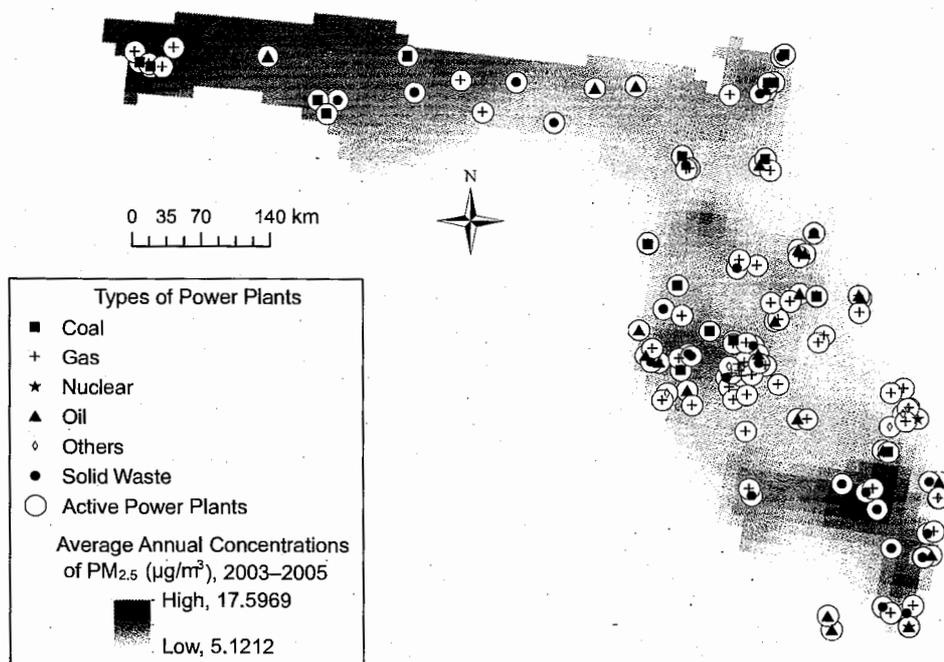


Figure 1. Geographical distribution of power plants and average annual levels of particulate matter less than 2.5 µm in diameter (PM_{2.5}) in Florida during the study period from 2003 to 2005.

percentages of people living closer to power plants were higher among those with adverse birth outcomes compared with those among controls. For example, among those with term LBW, the percentage of those who lived within 5 km

of any power plant (16.1%) was higher than that of controls (14.9%). Furthermore, among the case groups, the percentages of women who had lower education, were black, lived in neighborhoods with lower income, were unmarried, had no prenatal

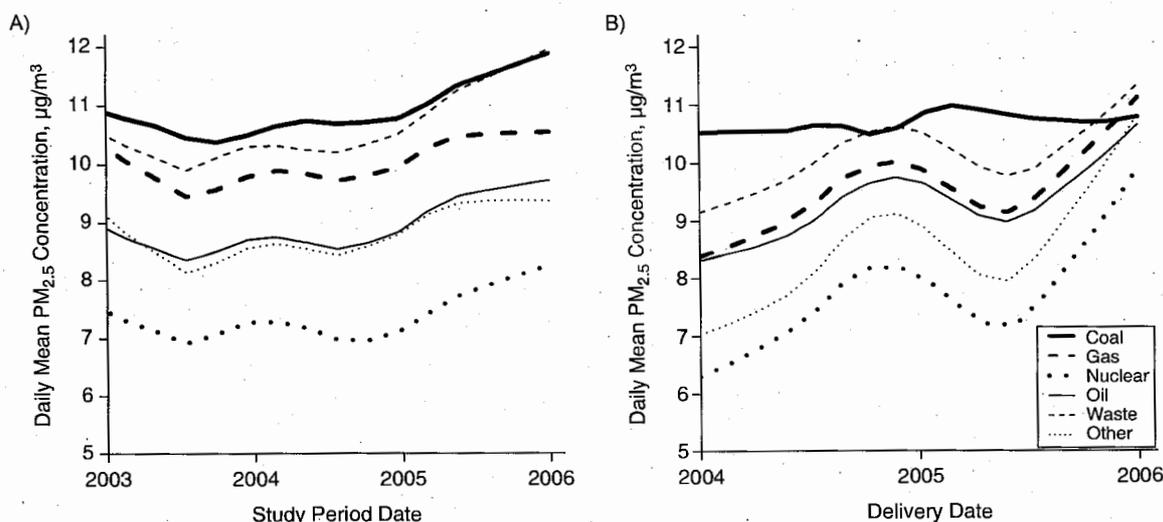


Figure 2. Exposures to levels of particulate matter less than 2.5 µm in diameter (PM_{2.5}) stratified by power plant type in Florida from 2003 to 2005. A) Daily concentrations of PM_{2.5} during the study period 2003–2005 at power plants; B) mean daily PM_{2.5} concentration at residential address during the first trimester for births in Florida from 2004 to 2005.

Table 3. Association Between Proximity to Power Plants, by Fuel Type, and Adverse Birth Outcomes in Florida From 2004 to 2005

Type of Power Plants	Term LBW		PTD		VPTD	
	aOR ^a	95% CI	aOR ^a	95% CI	aOR ^a	95% CI
<i>Continuous (for Each 5 km Closer in Distance)</i>						
Coal plant (n = 17)	1.02	0.98, 1.06	1.01	0.99, 1.03	1.03	0.98, 1.09
Gas plant (n = 66)	1.00	0.99, 1.02	1.02	1.01, 1.03	1.01	0.99, 1.03
Nuclear plant (n = 3)	1.07	0.96, 1.20	0.90	0.86, 0.95	0.99	0.87, 1.14
Oil plant (n = 28)	1.00	0.99, 1.02	1.02	1.01, 1.03	1.03	1.01, 1.06
Solid waste plant (n = 29)	1.03	1.01, 1.04	1.02	1.02, 1.03	1.02	1.00, 1.05
Other (n = 7)	1.05	0.96, 1.15	1.01	0.96, 1.06	1.03	0.91, 1.18
<i>Categorical (≤20 km Away vs. >20 km Away From All Plants)</i>						
Coal plant (n = 16)	1.19	0.98, 1.45	1.07	0.97, 1.18	1.19	0.93, 1.51
Gas plant (n = 67)	0.96	0.89, 1.04	1.09	1.04, 1.13	1.09	0.99, 1.20
Nuclear plant (n = 3)	1.37	0.81, 2.31	0.82	0.60, 1.11	0.88	0.39, 2.00
Oil plant (n = 28)	1.04	0.91, 1.19	1.14	1.06, 1.24	1.27	1.07, 1.52
Solid waste plant (n = 30)	1.10	1.00, 1.22	1.16	1.09, 1.22	1.15	1.01, 1.32
Other (n = 7)	1.16	0.68, 1.98	1.23	0.89, 1.70	1.39	0.61, 3.17

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; LBW, low birth weight; PTD, preterm delivery; VPTD, very preterm delivery.

^a Adjusted for maternal age, maternal race, marital status, census block group income, and urban neighborhood.

care, smoked, or drank alcohol during pregnancy were higher compared with those in the control group (Table 1).

Figure 1 shows a map of the spatial distribution of active power plants and the average annual PM_{2.5} concentrations in Florida during 2003–2005. There were 150 active nonrenewable power plants with different fuel types including 17 coal plants, 66 gas plants, 3 nuclear plants, 28 oil plants, 29 solid waste plants, and 7 plants with other types of fuel (e.g., coke, etc.). In general, PM_{2.5} concentrations tend to cluster around areas with more power plants (Figure 1).

Figure 2A and 2B illustrate PM_{2.5} exposure by types of power plants. In general, the concentrations of PM_{2.5} were highest around coal plants followed by solid waste, gas, oil, other, and nuclear plants (Figure 2A). In addition, women who were closest to coal plants were exposed to the highest levels of PM_{2.5} (mean = 10.7 (standard deviation (SD), 2.7) µg/m³) during the first trimester, followed by those living close to solid waste plants (mean = 10.1 (SD, 1.8) µg/m³), gas plants (mean = 9.5 (SD, 2.1) µg/m³), and oil plants (mean = 9.3 (SD, 1.8) µg/m³). Those who were closest to nuclear plants (mean = 7.7 (SD, 1.9) µg/m³) and “other” plants (mean = 8.5 (SD, 2.0) µg/m³) were exposed to the lowest levels of PM_{2.5} (Figure 2B; Web Table 1).

Table 2 provides the unadjusted and adjusted odds ratios for the association between proximity to power plants and term LBW, PTD, and VPTD. Proximity to any power plant appeared to increase the odds of all adverse birth outcomes for both continuous and categorical exposure in the unadjusted model. Moreover, these associations showed an exposure-response relationship with closer residents having the higher odds. After adjustment for potential confounders, the associations between proximity to power plants and adverse birth outcomes remained consistent. Specifically, for each 5-km

decrease in the distance to any power plant, the odds of term LBW, PTD, and VPTD increased by 1.1% (odds ratio (OR) = 1.011, 95% confidence interval (CI): 1.002, 1.020), 1.8% (OR = 1.018, 95% CI: 1.013, 1.023), and 2.2% (OR = 1.022, 95% CI: 1.010, 1.034), respectively. These associations remained consistent for PTD and VPTD when exposures were categorized (Table 2). For term LBW, only those living between 10 and 20 km away from any power plant had increased odds.

Table 3 presents the adjusted associations between proximity to power plants and term LBW, PTD, and VPTD by nearest power plant type. Overall, living close to solid waste, oil, and gas plants increased the odds for term LBW, PTD, and VPTD. In the continuous exposure analyses, only solid waste plants (OR = 1.03, 95% CI: 1.01, 1.04) had an association with term LBW for each 5-km decrease in distance. All types of plants had a slightly elevated association with PTD, except nuclear plants, which had a negative association (OR = 0.90, 95% CI: 0.86, 0.95), and “others” and coal plants with no associations. For VPTD, only oil and solid waste plants had significant associations. The results remained consistent when exposure was categorized (Table 3).

Because there was evidence of spatial clustering of power plants, distance from power plants may not be the best measure of exposure. We also created 20 km buffers around each birth and determined the total number of power plants within this buffer (Table 4). The association between adverse birth outcomes and total number of power plants within 20 km was determined. Compared with pregnant women who lived with no power plants within a 20 km radius, women living near ≥2 power plants had a 7% increased odds of term LBW (OR = 1.07, 95% CI: 1.01, 1.12), 12% increased odds of PTD (OR = 1.12, 95% CI: 1.09, 1.15), and 17% increased odds of VPTD (OR = 1.17, 95% CI: 1.09, 1.25). When stratified for different

Table 4. Association Between Number of Plants Within 20 km, by Fuel Type, and Adverse Birth Outcomes in Florida From 2004 to 2005

Type and No. of Power Plants Within 20 km	Term LBW		PTD		VPTD	
	aOR ^a	95% CI	aOR ^a	95% CI	aOR ^a	95% CI
All plants						
0	1.00	Referent	1.00	Referent	1.00	Referent
1	0.93	0.86, 1.01	1.08	1.04, 1.13	1.06	0.95, 1.17
≥2	1.07	1.01, 1.12	1.12	1.09, 1.15	1.17	1.09, 1.25
Coal plant						
0	1.00	Referent	1.00	Referent	1.00	Referent
1	0.93	0.87, 1.00	1.09	1.05, 1.13	0.99	0.91, 1.08
≥2	1.12	1.03, 1.22	1.20	1.14, 1.25	1.23	1.10, 1.36
Gas plant						
0	1.00	Referent	1.00	Referent	1.00	Referent
1	1.07	1.02, 1.13	1.05	1.02, 1.08	1.13	1.06, 1.21
≥2	1.06	1.00, 1.12	1.13	1.10, 1.17	1.13	1.06, 1.21
Oil plant						
0	1.00	Referent	1.00	Referent	1.00	Referent
1	1.07	1.02, 1.12	1.10	1.07, 1.12	1.18	1.12, 1.25
≥2	0.97	0.89, 1.06	0.99	0.95, 1.04	0.83	0.74, 0.94
Nuclear plant ^b						
0	1.00	Referent	1.00	Referent	1.00	Referent
≥1	1.03	0.93, 1.15	0.92	0.86, 0.98	0.88	0.75, 1.02
Solid waste plant						
0	1.00	Referent	1.00	Referent	1.00	Referent
1	1.08	1.04, 1.13	1.06	1.03, 1.09	1.13	1.06, 1.20
≥2	1.00	0.93, 1.07	1.09	1.06, 1.13	1.13	1.04, 1.22
Other plant						
0	1.00	Referent	1.00	Referent	1.00	Referent
1	0.94	0.87, 1.02	1.03	0.99, 1.08	1.07	0.98, 1.19
≥2	0.95	0.80, 1.14	0.86	0.78, 0.96	0.77	0.60, 0.99

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; LBW, low birth weight; PTD, preterm delivery; VPTD, very preterm delivery.

^a Adjusted for maternal age, maternal race, maternal education, marital status, census block group income, and urban neighborhood.

^b Nuclear plants are categorized differently because there are no births with 2 or more nuclear plants within 20 km.

types of power plants, the results remained generally consistent. Coal was strongly associated with all adverse birth outcomes (Table 4).

DISCUSSION

This study found that women with residential proximity to coal and solid waste plants were exposed to the highest concentrations of PM_{2.5} during the first trimester, and those closest to nuclear plants were exposed to the lowest concentrations. This pattern remained consistent when daily PM_{2.5} concentrations near different types of power plants were examined. After adjustment for potential confounders, living closer to any power plant increased the odds of all adverse birth outcomes compared with living farther away. We further identified that solid

waste plants had the strongest association with term LBW, while oil, gas, and solid waste plants all had strong associations with PTD and VPTD. The study also found that women living near 1 or more power plants located within a 20 km radius from their residence had higher odds of adverse birth outcomes. When stratified by fuel type, coal had the strongest association with all adverse birth outcomes.

Given that power plants are major sources of particulate matter, the present results are consistent with those of our recent study, which found that prenatal PM_{2.5} exposure was positively associated with LBW, PTD, and VPTD (23). During the study period, power plants in the United States emitted an estimated annual average of 2,491,971 metric tons of carbon dioxide, 10,431 metric tons of sulfur dioxide, and 4,212 metric tons of nitric oxides (27). These pollutants have been

linked to adverse birth outcomes in many studies. For example, higher exposure to sulfur dioxide has been linked to PTD among singleton births (28) and decreased term birth weight (29). In addition, nitric oxides have also been linked to term LBW and PTD (30, 31). Given the high emission of sulfur dioxide and nitric oxides from power plants and the positive association between these pollutants and adverse birth outcomes, it is plausible that proximity to power plants was associated with adverse birth outcomes. This finding has also been observed in Taiwan by Tsai et al. (20), who reported that the odds of PTD were 14 times higher among women who lived within 3 km of a thermal power plant compared with those who lived farther than 3 km.

When stratified by type of plants in order to compare birth outcomes among women who lived close to or farther from different types of power plants, our data showed that solid waste plants had associations with all adverse birth outcomes. In addition, when exposure was changed to number of plants within 20 km, coal plants had the highest association with all adverse birth outcomes. These findings are consistent with the fact that coal and solid waste power plants produce relatively larger amounts of particulate emissions compared with other types of power plants. Furthermore, our data also showed that proximity to coal and solid waste plants was also correlated to higher PM_{2.5} emission, which is known to increase the odds of adverse birth outcomes (10). With coal combustion accounting for approximately 45% of electricity produced in the United States, it may pose a serious public health issue. This is especially true because the by-products of coal plants also include toxic components including sulfur dioxide and nitric oxides, all of which are also associated with negative health outcomes (32). We also found that gas and oil plants had a positive association with adverse birth outcomes, especially PTD and VPTD. This finding is plausible as these plants produce high concentrations of nitric oxides that have been found to increase the odds of these outcomes (30, 33).

Our continuous exposure analysis showed that proximity to nuclear plants was protective against PTD, but not term LBW or VPTD. In categorical exposure analyses, no association was found. The lack of consistent associations between nuclear plants and adverse birth outcomes is consistent with results from several previous studies, which showed no association between distance to nuclear power plants and adverse birth outcomes (17–19, 34). The lack of a positive association could be explained by the fact that, compared with other types of plants, nuclear plants do not emit as many atmospheric pollutants in high concentrations (e.g., PM_{2.5}, sulfur dioxide, and nitric oxides) (35). This association is also consistent with our data that showed, on average, that women close to nuclear plants and other plants were exposed to lower levels of PM_{2.5}.

Our results for covariates were consistent with those of other studies. For example, the fact that our study showed an increased proportion of females among the term LBW group and a decreased proportion of females among the PTD and VPTD groups confirmed previous findings. On average, males weigh 150 and 200 g more than females (36) given term birth, and they have a 9%–24% increased risk for PTD (37). In addition, our observation that pregnant women who had a lower level of education, were racial minorities and unmarried, had no prenatal care, used tobacco, and smoked

during pregnancy were more likely to be in the adverse birth outcome groups is also consistent with the literature (38–40). It is possible that socioeconomic status confounded the association that we observed in this study. However, in addition to adjustment for maternal education, which serves as a proxy for socioeconomic status, we also adjusted for census-tract-level median household income from the US Census 2000 to control for ecological (or population-level) socioeconomic status factors.

Like most retrospective studies, this study has several limitations. First, analysis of proximity as both a continuous variable and as a categorical variable addresses exposure-response relationships, but it does so in different ways with different assumptions. In the categorical exposure analyses, we made a fundamental assumption that each power plant has a uniform effect on participants within a certain buffer. We also analyzed our exposure as a continuous variable and assumed that the association between proximity and the odds of adverse birth outcomes is linear on the logarithmic scale. When the results for both analyses were compared, the conclusions were consistent, although those for categorical exposure are stronger. One of the reasons for the differences may be a result of the spatial clustering of power plants. To ensure that clustering was not influencing our results, we performed a sensitivity analysis using the number of power plants within 20 km as exposure. This analysis yielded results consistent with proximity to power plants as a measure of exposure.

Although we chose PM_{2.5} to “validate” our exposure, power plants also emit other gaseous pollutants including carbon oxides, sulfur dioxide, and nitric oxides (41), all of which are highly correlated (30). Because of the use of proximity and the unavailability of specific pollutant data from the US Environmental Protection Agency’s Hierarchical Bayesian Prediction Model, we were unable to disentangle the specific pollutant. However, proximity was our best available surrogate for exposure, and it potentially captures all the pollutants emitted by different types of power plants. Additionally, we were not able to identify critical windows of exposure that underlie these associations. Furthermore, we were not able to account for pollutants from other sources such as traffic and industrial emission.

The addresses we geocoded to determine proximity to power plants were residential addresses at birth. This method assumes that pregnant women stayed at those same addresses throughout their pregnancy. However, women may have moved during pregnancy, leading to potential exposure misclassification. We unfortunately did not have residential mobility information to address this issue. However, studies on residential mobility and its effects on air pollution assessment suggest a very low degree of misclassification (42, 43).

We were also unable to adjust for daily activities patterns. Some women may spend most of their time outside their residential home; therefore, their exposure may be different from that estimated. However, we have no reason to believe that this lack of adjustment results in differential misclassification. Therefore, this discrepancy is likely to bias our results toward the null. Consequently, daily activity patterns cannot entirely explain the increased risk that we found.

One may argue that potential confounding may be caused by other variables that we did not adjust for. However, we have

also used a fully adjusted model with all covariates in our directed acyclic graph. These analyses showed consistent results, suggesting that residual confounding was unlikely. Finally, the Hierarchical Bayesian Prediction Model data that we used to describe PM_{2.5} exposures were available at only 12 × 12 km resolution. Therefore, we were not able to account for local variation smaller than this spatial resolution.

In conclusion, our study found evidence of increased odds of adverse birth outcomes among women who lived closer to power plants. This association remained consistent in our analyses for total number of power plants within a 20 km radius and stratified analyses for different types of power plants. These results call for further investigation to confirm our results and to investigate the specific pollutants generated from power plants that are responsible for this association.

ACKNOWLEDGMENTS

Author affiliations: Department of Epidemiology, College of Public Health and Health Professions and College of Medicine, University of Florida, Gainesville, Florida (Sandie Ha, Hui Hu, Xiaohui Xu); Department of Pediatrics, College of Medicine, University of Florida, Gainesville, Florida (Jeffrey Roth); and Shanghai Key Laboratory of Atmospheric Particle Pollution and Prevention (LAP3), School of Public Health, Fudan University, Shanghai, People's Republic of China (Haidong Kan).

This work was supported by grant K01ES019177 from the National Institute of Environmental Health Sciences (X.X.) and a University of Florida Graduate School fellowship (S.H.).

We wish to thank the Florida Department of Health for supplying the data.

The content of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of the funders or data provider.

Conflict of interests: none declared.

REFERENCES

1. Brook RD, Rajagopalan S, Pope CA 3rd, et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation*. 2010;121(21):2331–2278.
2. Peacock JL, Anderson HR, Bremner SA, et al. Outdoor air pollution and respiratory health in patients with COPD. *Thorax*. 2011;66(7):591–596.
3. Teng TH, Williams TA, Bremner A, et al. A systematic review of air pollution and incidence of out-of-hospital cardiac arrest. *J Epidemiol Community Health*. 2014;68(1):37–43.
4. Dominici F, Peng RD, Bell ML, et al. Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. *JAMA*. 2006;295(10):1127–1134.
5. Halonen JJ, Lanki T, Yli-Tuomi T, et al. Urban air pollution, and asthma and COPD hospital emergency room visits. *Thorax*. 2008;63(7):635–641.
6. Neuberger M, Moshhammer H, Rabczenko D. Acute and subacute effects of urban air pollution on cardiopulmonary emergencies and mortality: time series studies in Austrian cities. *Int J Environ Res Public Health*. 2013;10(10):4728–4751.
7. Romieu I, Gouveia N, Cifuentes LA, et al. Multicity study of air pollution and mortality in Latin America (the ESCALA study). *Res Rep Health Eff Inst*. 2012;(171):5–86.
8. Simpson R, Williams G, Petroschevsky A, et al. The short-term effects of air pollution on daily mortality in four Australian cities. *Aust N Z J Public Health*. 2005;29(3):205–212.
9. Fann N, Lamson AD, Anenberg SC, et al. Estimating the national public health burden associated with exposure to ambient PM_{2.5} and ozone. *Risk Anal*. 2012;32(1):81–95.
10. Stieb DM, Chen L, Eshoul M, et al. Ambient air pollution, birth weight and preterm birth: a systematic review and meta-analysis. *Environ Res*. 2012;117:100–111.
11. Vrijheid M, Martinez D, Manzanares S, et al. Ambient air pollution and risk of congenital anomalies: a systematic review and meta-analysis. *Environ Health Perspect*. 2011;119(5):598–606.
12. Xu X, Hu H, Ha S, et al. Ambient air pollution and hypertensive disorder of pregnancy. *J Epidemiol Community Health*. 2014;68(1):13–20.
13. Hu H, Ha S, Roth J, et al. Ambient air pollution and hypertensive disorders of pregnancy: a systematic review and meta-analysis. *Atmos Environ*. 2014;97:336–345.
14. American Lung Association. *Toxic Air: The Case for Cleaning Up Coal-fired Power Plants*. Washington, DC: American Lung Association; 2011.
15. US Environmental Protection Agency. Reducing air pollution from power plants. <http://www.epa.gov/airquality/powerplants/>. Published March 27, 2012. Updated March 27, 2012. Accessed December 6, 2014.
16. Environmental Integrity Project. *US Power Plant Global Warming Emissions Rising in 2013 After Years of Decline*. Washington, DC: Environmental Integrity Project; 2013.
17. Queisser-Luft A, Wiesel A, Stolz G, et al. Birth defects in the vicinity of nuclear power plants in Germany. *Radiat Environ Biophys*. 2011;50(2):313–323.
18. Mangones T, Visintainer P, Brumberg HL. Congenital anomalies, prematurity, and low birth weight rates in relation to nuclear power plant proximity. *J Perinat Med*. 2013;41(4):429–435.
19. Wang SI, Lee LT, Zou ML, et al. Pregnancy outcome of women in the vicinity of nuclear power plants in Taiwan. *Radiat Environ Biophys*. 2010;49(1):57–65.
20. Tsai SS, Yu HS, Chang CC, et al. Increased risk of preterm delivery in women residing near thermal power plants in Taiwan. *Arch Environ Health*. 2004;59(9):478–483.
21. Buonocore JJ, Dong X, Spengler JD, et al. Using the Community Multiscale Air Quality (CMAQ) Model to estimate public health impacts of PM_{2.5} from individual power plants. *Environ Int*. 2014;68:200–208.
22. Zhu X, Liu Y, Chen Y, et al. Maternal exposure to fine particulate matter (PM) and pregnancy outcomes: a meta-analysis. *Environ Sci Pollut Res Int*. 2015;22(5):3383–3396.
23. Ha S, Hu H, Roussos-Ross D, et al. The effects of air pollution on adverse birth outcomes. *Environ Res*. 2014;134:198–204.
24. Hodges A, Rahmani M. Fuel sources and carbon dioxide emissions by electric power plants in the United States. <https://edis.ifas.ufl.edu/fe796>. Published March 2009. Updated January 2012. Accessed March 8, 2014.
25. McMillan N, Holland DM, Morara M, et al. Combining different sources of particulate data using Bayesian space-time modeling. *Environmetrics*. 2009;21(1):48–65.
26. Lee PC, Roberts JM, Catov JM, et al. First trimester exposure to ambient air pollution, pregnancy complications and adverse birth outcomes in Allegheny County, PA. *Matern Child Health J*. 2013;17(3):545–555.

27. US Energy Information Administration. Electric power annual: emission from energy consumption at conventional power plants and combined-heat-and-power plants 2002–2012. http://www.eia.gov/electricity/annual/html/epa_09_01.html. Published December 12, 2013. Accessed December 17, 2014.
28. Liu S, Krewski D, Shi Y, et al. Association between gaseous ambient air pollutants and adverse pregnancy outcomes in Vancouver, Canada. *Environ Health Perspect*. 2003;111(14):1773–1778.
29. Geer LA, Weedon J, Bell ML. Ambient air pollution and term birth weight in Texas from 1998 to 2004. *J Air Waste Manag Assoc*. 2012;62(11):1285–1295.
30. Wilhelm M, Ghosh JK, Su J, et al. Traffic-related air toxics and term low birth weight in Los Angeles County, California. *Environ Health Perspect*. 2012;120(1):132–138.
31. Wu J, Ren C, Delfino RJ, et al. Association between local traffic-generated air pollution and preeclampsia and preterm delivery in the south coast air basin of California. *Environ Health Perspect*. 2009;117(11):1773–1779.
32. Environmental Health & Engineering, Inc. *Emissions of Hazardous Air Pollutants from Coal-fired Power Plants*. Needham, MA: Environmental Health & Engineering, Inc; 2011.
33. Lee BE, Ha EH, Park HS, et al. Exposure to air pollution during different gestational phases contributes to risks of low birth weight. *Hum Reprod*. 2003;18(3):638–643.
34. Siffel C, Otos M, Czeizel AE. Congenital abnormalities and indicators of germinal mutations in the vicinity of the Paks nuclear plant, Hungary. *Mutagenesis*. 1996;11(3):299–303.
35. US Environmental Protection Agency. Clean energy: air emissions. <http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html>. Updated May 22, 2014. Accessed December 17, 2014.
36. Valero De Bernabé J, Soriano T, Albaladejo R, et al. Risk factors for low birth weight: a review. *Eur J Obstet Gynaecol Reprod Biol*. 2004;116(1):3–15.
37. Zeitlin J, Saurel-Cubizolles MJ, De Mouzon J, et al. Fetal sex and preterm birth: Are males at greater risk? *Hum Reprod*. 2002;17(10):2762–2768.
38. Chang SC, O'Brien KO, Nathanson MS, et al. Characteristics and risk factors for adverse birth outcomes in pregnant black adolescents. *J Pediatr*. 2003;143(2):250–257.
39. Centers for Disease Control and Prevention. Birth outcome and risk factor analysis. http://www.cdc.gov/pednss/how_to/read_a_data_table/prevalence_tables/birth_outcome.htm. Updated March 4, 2010. Accessed November 8, 2013.
40. Graham J, Zhang L. Factors associated with negative birth outcomes: findings from a birth cohort study. http://msdh.ms.gov/msdhsite/_static/resources/2546.pdf. Updated January 15, 2015. Accessed January 24, 2015.
41. Vijayaraghavan K, Seigneur C, Bronson R, et al. A case study of the relative effects of power plant nitrogen oxides and sulfur dioxide emission reductions on atmospheric nitrogen deposition. *J Air Waste Manag Assoc*. 2010;60(3):287–293.
42. Chen L, Bell EM, Caton AR, et al. Residential mobility during pregnancy and the potential for ambient air pollution exposure misclassification. *Environ Res*. 2010;110(2):162–168.
43. Oudin A, Forsberg B, Strömberg M, et al. Impact of residential mobility on exposure assessment in longitudinal air pollution studies: a sensitivity analysis within the ESCAPE Project. *Sci World J*. 2012;2012:125818.

Appendix G

Preterm Birth

Preterm birth is when a baby is born too early, before 37 weeks of pregnancy have been completed. In 2016, preterm birth affected about 1 of every 10 infants born in the United States. Preterm birth rates decreased from 2007 to 2014, and [CDC research \(https://www.cdc.gov/mmwr/volumes/65/wr/mm6543a1.htm\)](https://www.cdc.gov/mmwr/volumes/65/wr/mm6543a1.htm) shows that this decline is due, in part, to declines in the number of births to teens and young mothers. However, the preterm birth rate rose for the second straight year in 2016. Additionally, racial and ethnic differences in preterm birth rates remain. For example, in 2016, the rate of preterm birth among African-American women (14%) was about 50 percent higher than the rate of preterm birth among white women (9%).



A developing baby goes through important growth throughout pregnancy—including in the final months and weeks. For example, the brain, lungs, and liver need the final weeks of pregnancy to fully develop. Read [Your Baby Grows Throughout Your Entire Pregnancy](#) [PDF-312KB]. Babies born too early (especially before 32 weeks) have higher rates of death and disability. In 2015, preterm birth and low birth weight accounted for about 17% of infant deaths. Babies who survive may have

- Breathing problems
- Feeding difficulties
- [Cerebral palsy \(https://www.cdc.gov/ncbddd/dd/ddcp.htm\)](https://www.cdc.gov/ncbddd/dd/ddcp.htm)
- [Developmental delay \(https://www.cdc.gov/ncbddd/developmentaldisabilities/index.html\)](https://www.cdc.gov/ncbddd/developmentaldisabilities/index.html)
- [Vision problems \(https://www.marchofdimes.org/complications/retinopathy-of-prematurity.aspx\)](https://www.marchofdimes.org/complications/retinopathy-of-prematurity.aspx)
- [Hearing problems \(https://www.cdc.gov/ncbddd/hearingloss/index.html\)](https://www.cdc.gov/ncbddd/hearingloss/index.html)

Preterm births may also take an emotional toll and be a financial burden for families.

Frequently Asked Questions: For Women and Their Families

- › **What are the warning signs of preterm labor?**
- › **What should I do if I think I'm experiencing preterm labor?**
- › **Are some women more likely than others to deliver early?**
- › **Can anything be done to prevent a preterm birth?**

> I used in vitro fertilization (IVF) or another assisted reproductive technology (ART) to get pregnant. What is my risk of having a preterm birth?

> Is it okay to schedule my baby's birth before 39 weeks of pregnancy?

What is CDC's Division of Reproductive Health doing to prevent preterm birth?

CDC's Division of Reproductive Health is engaged in a variety of research and science to practice activities aimed at understanding and reducing preterm birth. CDC scientists are collaborating with many partners, including state health departments, university researchers, and other health care professionals to understand why preterm births occur and what can be done to help prevent them. [Read about our preterm birth activities.](#)

Public Health Grand Rounds

CDC's [Public Health Grand Rounds](#) is a  a physician's open hands and the words public health grand rounds monthly webcast created to foster discussion on major public health issues. The November 2015 session, Public Health Strategies to Prevent Preterm Birth, discusses how concerted efforts to improve surveillance data, better medical care and prevention, and stronger public health partnerships, can accelerate progress in reducing preterm births and improving neonatal outcomes. [View the archived presentation](#) and [publication](#)

Related Links

- [Is It Worth It?](http://www.nichd.nih.gov/ncmhhep/isitworthit/pages/default.aspx) (http://www.nichd.nih.gov/ncmhhep/isitworthit/pages/default.aspx) Information from the National Child and Maternal Health Education Program to learn the benefits of waiting until 39 weeks to deliver.
- [Premature Babies](https://www.marchofdimes.org/complications/premature-babies.aspx) (https://www.marchofdimes.org/complications/premature-babies.aspx) Information about health problems among and care of premature babies from the March of Dimes.
- [Preterm Labor and Birth \(ACOG\) \[PDF - 282KB\]](http://www.acog.org/Patients/FAQs/Preterm-Premature-Labor-and-Birth) (http://www.acog.org/Patients/FAQs/Preterm-Premature-Labor-and-Birth) Information from the American College of Obstetricians and Gynecologists (ACOG).

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Page last updated: April 24, 2018

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Appendix H

YOU CAN SAVE A CHILD LIKE KAYA



Your monthly support gives hope and saves lives.



GIVE NOW

PREMATURE BABIES

A premature baby is one who is born too early, before 37 weeks. Premature babies may have more health problems and may need to stay in the hospital longer than babies born later.

They also may have [long-term health problems](#) that can affect their whole lives. About 1 in 10 babies is born prematurely each year in the United States.

The earlier in pregnancy a baby is born, the more likely he is to have health problems. Some premature babies have to spend time in a hospital's neonatal intensive care unit (also called NICU). This is the part of a hospital that takes care of sick newborns. But thanks to advances in medical care, even babies born very prematurely are more likely to survive today than ever before.

What health problems can premature babies have after birth?

Health problems that may affect premature babies include:

- **Apnea.** This is a pause in breathing for 20 seconds or more. Premature babies sometimes have apnea. It may happen together with a slow heart rate.
- **Respiratory distress syndrome (RDS).** This is a breathing problem most common in babies born before 34 weeks of pregnancy. Babies with RDS don't have a protein called surfactant that keeps small air sacs in the lungs from collapsing.
- **Intraventricular hemorrhage (IVH).** This is bleeding in the brain. It usually happens near the ventricles in the center of the brain. A ventricles is a space in the brain that's filled with fluid.
- **Patent ductus arteriosus (PDA).** This is a heart problem that happens in the connection (called the ductus arteriosus) between two major blood vessels near the heart. If the ductus doesn't close properly after birth, a baby can have breathing problems or heart failure. Heart failure is when the heart can't pump enough blood.
- **Necrotizing enterocolitis (NEC).** This is a problem with a baby's intestines. It can cause feeding problems, a swollen belly and diarrhea. It sometimes happens 2 to 3 weeks after a premature birth.
- **Retinopathy of prematurity (ROP).** This is an abnormal growth of blood vessels in the eye. ROP can lead to vision loss.
- **Jaundice.** This is when a baby's eyes and skin look yellow. A baby has jaundice when his liver isn't fully developed or isn't working well.
- **Anemia.** This is when a baby doesn't have enough healthy red blood cells to carry oxygen to the rest of the body.
- **Bronchopulmonary dysplasia (BPD).** This is a lung condition that can develop in premature babies as well as babies who have treatment with a breathing machine. Babies with BPD sometimes develop fluid in the lungs, scarring and lung damage.
- **Infections.** Premature babies often have trouble fighting off germs because their immune systems are not fully formed. Infections that may affect a premature baby include [pneumonia](#), a lung infection; sepsis, a blood infection; and [meningitis](#), an infection in the fluid around the brain and spinal cord.

How can you best care for your premature baby?

Talk to your baby's health care providers about any health conditions your baby has. He may be healthy enough to go home soon after birth, or he may need to stay in the NICU for special care. Your baby can probably go home from the hospital when he:

- Weighs at least 4 pounds
- Can keep warm on his own, without the help of an incubator. An incubator is an enclosed unit that helps premature babies stay warm.



**YOU CAN SAVE A CHILD
LIKE KAYA**
(2 to 1 hour each day)

Your monthly support gives hope and saves lives.

GIVE NOW

Your baby may need [special equipment](#), [treatment or medicine](#) after he [leaves the hospital](#). Your baby's provider and the [staff at the hospital](#) can help you with these things and teach you how to take care of your baby. They also can help you find parent support groups and other resources in your area that may be able to help you care for your baby.

See also: [March of Dimes Prematurity Campaign](#), [The NICU Family Support program](#)

Last reviewed: October, 2013



YOU CAN SAVE A CHILD LIKE KAYA

Your monthly support gives hope and saves lives.

GIVE NOW

Appendix I

An official website of the United States government.

We've made some changes to EPA.gov. If the information you are looking for is not here, you may be able to find it on the EPA Web Archive or the January 19, 2017 Web Snapshot.

Close



Basic Information about NO₂

On This Page:

- [What is NO₂ and how does it get in the air?](#)
- [What are the harmful effects of NO₂?](#)
- [What is being done to reduce NO₂ pollution?](#)

What is NO₂ and how does it get in the air?

Nitrogen Dioxide (NO₂) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NO_x). Other nitrogen oxides include nitrous acid and nitric acid. NO₂ is used as the indicator for the larger group of nitrogen oxides.

NO₂ primarily gets in the air from the burning of fuel. NO₂ forms from emissions from cars, trucks and buses, power plants, and off-road equipment.

Effects of NO₂

Health effects

Breathing air with a high concentration of NO₂ can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), hospital admissions and visits to emergency rooms. Longer exposures to elevated concentrations of NO₂ may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of NO₂.

NO₂ along with other NO_x reacts with other chemicals in the air to form both particulate matter and ozone. Both of these are also harmful when inhaled due to effects on the respiratory system.

- [Learn more about Particulate Matter and Ozone.](#)

Environmental effects

NO₂ and other NO_x interact with water, oxygen and other chemicals in the atmosphere to form acid rain. Acid rain harms sensitive ecosystems such as lakes and forests.

- Learn more about [Acid Rain](#).

The nitrate particles that result from NO_x make the air hazy and difficult to see through. This affects the many national parks that we visit for the view.

- Learn more about [Visibility and Haze](#).

NO_x in the atmosphere contributes to nutrient pollution in coastal waters.

- Learn more about [Nutrient Pollution](#).

What is being done to reduce NO₂ pollution?

EPA's national and regional rules to reduce emissions of NO₂ and NO_x will help state and local governments meet the National Ambient Air Quality Standard (NAAQS).

- Learn about [how air quality standards help reduce NO₂](#)

EPA identifies areas where the air quality does not meet the national NO₂ standards. For these areas, state, local, and tribal governments develop plans to reduce the amount of NO₂ in the air.

- Learn more about [NO₂ air quality designations and state implementation plans \(SIPs\)](#).

LAST UPDATED ON SEPTEMBER 8, 2016