Particulate Air Pollution and Adverse Birth Effects

How many studies have been done in Utah?

One study in Utah: Parker 2008 – Utah Valley. Studied Geneva Steel closure in 1987 for effect on pre-term birth. Nearly all data not significant.

One included some from Utah: Woodruff 2008 – studied US counties >250,000 residents.

What are the most common diseases studied/reported?

- Preterm Births (Hertz-Picciotto 2002, Lee 2008, Zhao 2011, Yorifuji 2011, Yang 2003, 2004, Wu 2009, Olsson 2012, Maroziene 2002)
- Preeclampsia (Wu 2009)
- Low birth weight (Siddiqui 2008, Dugandzic 2006, Salam 2005, Maroziene 2002)
- Gestational Age

What is the magnitude of impact (both small and large) in terms of odds ratios?

OR=1.10 preterm birth in winter vs. summer (Hertz-Picciotto 2002)
OR=1.9 preterm birth and proximity to major roads (200m) (Yorifuji 2011)
OR=1.14 preterm birth for petroleum exposed areas (Yang 2004)
OR=1.30 preterm birth and proximity to freeways (<500m) (Yang 2003)
OR=1.04 preterm birth and air pollution (Woodruff 2003)

OR=1.86 low birth weight and exposure to wood fuel burning (Siddiqui 2008)
OR=1.33 low birth weight and exposure to PM10 in first trimester (Dugandzic 2006)
OR=1.23 low birth weight and exposure to PM10 in first trimester (Hansen 2007)
OR=3.06 low birth weight and exposure to total suspended particles (Rogers 2000)

OR=1.21 preclampsia and exposure to ozone (Wu 2011)

Is there increasing occurrence of disease with increasing exposure?

Hertz-Picciotto 2002 concluded that "higher particulate matter during pregnancy is associated with higher NK cell fractions in newborns and, in maternal blood, a lower percentage of T-cells, a lower percentage of CD3-CD4- calls, and a reduced CD4+:CD8+ cell ratio"

The odds ratio for low birth weight increased by 1.11 for each 100 $\mu g/m^3$ of SO_2 (1.12; 95% CI 1.03-1.22) and 1.10 for TSP (1.10; 95% CI 1.01-1.20). (Wang 1997)

The risk of preterm birth increased 25% per 10 $\mu g/m^3$ NO_2 concentration (OR=1.25; 95% CI 1.07-1.46). (Maroziene 2002)

"LBW outcomes were increased by a 10-$\mu g/m^3$ in average ambient PM_{10} concentration during the first (odds ratio- 1.1; 95% CI 1.0-1.2), second (1.1; 0.9-1.2), and third trimesters (1.1; 1.0-1.2). A 10-$\mu g/m^3$ increase in PM_{10} exposure during the second and third trimesters was not significantly associated with decreased birth weight by 0.3g (95% CI -7.3 to 6.8) and 2.1g (-7.5-3.4)." (Kim 2007)

For each 1 $\mu g/m^3$ increase of PM_{10} the odds of having C-reactive protein concentrations over 8 1 µg/mL was not significantly elevated at 1.23 (95% CI 0.97-1.57). For each IQR increase of $PM_{2.5}$ there was 2% increase in C-reactive protein. O_3 was associated with non-significant elevated levels of C-reactive protein (1.05 (95% CI 0.65-1.71). (Lee 2011)

Increase in mean exposure in CO of 1 ppm during first trimester of pregnancy was associated with a reduction of about 23g in birth weight. For a 10 $\mu g/m^3$ change in PM_{10} there was a 13.7g reduction. (Gouveia 2003)

Do women who live from 50 to 500 meters to a highway (without traffic lights or stop signs) have a shorter gestation time and increased risk of negative birth outcomes?

Exposure to traffic pollution for those mothers living within 50-200 meters of a highway have an increased risk of shorter gestation times (Barnett, 2011, Genereux, 2007, Brauer, 2008). The prevalence of deliveries of preterm birth infants was significantly higher among mothers who lived within 500 m of the freeway than among mothers who resided 500–1,500 (Yang, 2003).

Traffic air pollution plays a role in adverse pregnancy outcomes. However, across studies, no consistent associations were observed between distance to road and negative birth outcomes (van den Hooven, 2009), but rather one of the seven studies found an association to exist based on the number of roads (Barnett, 2011).

References:

(Australia, N = 970)

In 2011, a study by Barnett et al examined exposure to traffic pollution within 400 meters of a highway found some evidence of shorter gestation times for women living nearer to a major road at p = 0.073. A gestation time was associated with increased freeways or 4.4% shorter. However, there was an association between distance to freeway and odds of smoking at both a mother and household level. (Barnett, 2011) Residence within 50 m of highways was associated with a 26% increase in SGA [95% confidence interval (CI), 1.07–1.49] and an 11% (95% CI, 1.01–1.23) increase in LBW. No association with negative birth outcomes and distance to road but rather association exists using the number of roads. **(Barnett, 2011)**

(Japan, N = 14,266)

In 2011, Yorifuji found that living within 200 m increased the risk of preterm births of less than 37 weeks by 1.5 times (95% CI 1.2–1.8), preterm births of less than 32 weeks by 1.6 times (1.1–2.4), and preterm births of less than 28 weeks by 1.8 times (1.0 –3.2). Also, there was a positive association between proximity to major roads within 200 m and preterm births with PPROM 1.9 (1.3–2.8) or with pregnancy hypertension 2.0 (1.2–3.3). **(Yorifuji, 2011)**

(Germany, N = 7600)

Estimated average pregnancy exposures were high (>75 mg/m3) for 11 participants, who all lived within 50 m of a highway. **(Gehring, 2010)**

(Netherlands, N = 7,339)

Participants lived within 50 m of a major road, are observed to have a significant associations between the second DWTD quartile and the risk for preterm birth, and between living 100 to 150 m from a major road and birth weight. No consistent associations were observed between traffic exposure and pregnancy complications. **(van den Hooven, 2009)**

(Canada, N = 70, 249)
A strong association was observed for mothers who resided within 50 m of an expressway or highway. No increased risk was observed for those living within 150 m of a highway or within 50 m of a major road (15,000–18,000 vehicles per day). Residence within 50 m of highways was associated with a 26% increase in SGA [95% confidence interval (CI), 1.07–1.49] and an 11% (95% CI, 1.01–1.23) increase in LBW. **(Brauer, 2008)**
(Canada, N = 99, 819)
Those mothers residing in proximity of 200 m of a highway, (6.0%) had a higher frequency of PTB (7.0%), LBW (5.3%) and SGA birth (9.8%) relative to mothers residing further away. The odds of living within 200 m of a highway were the highest in the poorest neighborhoods. **(Genereux, 2007)**
(Taiwan, N = 6,251)
The prevalence of preterm deliveries within 500 m, and between 500 m and 1,500 m, of the freeway were significant at 5.29% and 4.08%, respectively. Adjusting for maternal age, season, marital status, maternal education, and infant gender, the adjusted OR was 1.30 (95% CI = 1.03, 1.65) for delivery of preterm infants to mothers who lived close to the freeway (i.e., 500 m) vs. mothers who lived between 500 m and 1,500 m from the freeway. **(Yang, 2003)**

Is there a time during pregnancy that pollution is especially harmful to the fetus?

Ritz, 2000 found that increased exposure to PM_{10} during the last last 6 weeks of pregnancy leads to an increase of preterm birth of about 20% and during the first month of pregnancy is about a 16% increase. Similar results were found with an increase of 3 ppm CO leading to a 12% increase of preterm birth with exposure in the last 6 weeks and a 4% increase with exposure in the first month of pregnancy. Similar results were found from Suh, 2008. Suh found that the risks for preterm birth attributed to PM_{10} were significantly higher in the third trimester.
Ritz, 2002 found that increased exposure to ozone and CO in the second month increased risks for ventricular septal defects.
Wilhelm, 2005 found a 12% increase in low birth weight per 1-ppm increase of CO in the third trimester, but no effects were seen for the other 2 trimesters between CO or PM_{10} concentrations and low birth weight.
It seems that the fetus is most susceptible to harm from pollution in the first month and last trimester of pregnancy. However, these results can vary and researchers have not come to a consensus.

What information is specific to the United States?

Wu, 2009
Woodruff, 2003
Salam, 2005
Xu, 2011
Wu, 2011
Lee, 2011
Basu, 2004
Wilhelm, 2011
Wilhelm, 2003
Rogers, 2000
Ritz, 2007
Marshall, 2009

Huynh, 2006
Rogers, 2013
Ritz, 2000
Ritz, 2002
Rudra, 2011
Sagiv, 2005
Vinikoor-Imlet, 2011
Wilhelm, 2005
Woodruff, 2008
Woodruff, 1997
Darrow, 2009
Chang, 2011
Bell, 2007
Ritz, 2006
Rich, 2008
Ponce, 2005
Parker, 2005
Gilboa, 2005
Le, 2012
Parker, 2008
Morello-Frosch, 2010
Padula, 2012
Maisonet, 2001

What is the average weight reduction of a fetus exposed to air pollution during gestation?

Gouveia et al (2003) found that an increase in CO of 1 ppm during the first trimester of pregnancy was associated with an average weight reduction of 23g in birth weight. Similarly, for every 10 μg/m^3 increase in PM_{10} there was a 13.7g reduction. Madsen (2010) found that women exposed to air pollution had on average a 47.5g reduction in fetus birth weight. Van den Hooven (2012) found that PM_{10} and NO_2 exposure levels were associated with a reduction of 13g and 46g in the third-trimester and birth weight, even after controlling for smoking, alcohol, and folic acid supplementation. Yorifuji (2011) found that preterm births on average had a weight of 1940 +/- 683g compared to full-term births weight 2998 +/- 380g in a cohort of over 13,000 births controlling for age, BMI, smoking status, gestational age, and proximity to roads. Siddiqui (2008) found that women using wood burning stoves or ovens had an birth weight reduction average of 82g, after controlling for socioeconomic status, smoking status, prenatal checkups, type of home, and crowding index. Kim (2007) found that a 10-μg/m^3 increase in PM_{10} during the second and third trimesters decreased birth weight by 0.3g and 2.1g (after controlling for confounders). Lastly, Bobak (2001) found that mothers living in higher polluted areas of the United Kingdom on average had babies weighing 87g less that mothers that lived in the least polluted areas. The authors controlled for social class, education, and geographic region. Lee (2003) found that for every interquartile increase of PM_{10}, SO_2, and NO_2 during second trimester, reduced birth weight by 19.6g, 14.6g, and 21.5g. Bobak (2000) found that an increase of SO2 and TSP by 50 μg/m^3 during the first trimester was associated with a reduction in mean birth weight by 11.4g and 10.8g. Ballester (2010) noted that NO2 exposure levels over 40 μg/m^3 during the first trimester was associated with an average birth weight reduction of 40.3g, after controlling for SES, smoking, weight, sex, BMI, season of delivery, and age.

Note: 2500 g = 5 lbs 8 oz
Low birth weight is considered <2500g

For those babies born preterm due to pollution, what is the average gestational period? Zhao (2011) found that ambient air pollutants (NO_2, PM_{10}, and SO_2) were associated with an average gestational reduction of 21.47 days. Bobak (2000) found that for every SO_2 and TSP increase of 50 $\mu g/m^3$ during the first trimester, reduced gestational period by 0.056 weeks and 0.075 weeks, respectively. Ritz (2000) found that mean gestational length was reduced by 0.90 days (after adjusting for covariates) for each 50 $\mu g/m^3$ increase of PM_{10} during the last 6 weeks before birth.

Note: normal gestational period is 266 days (38 weeks), preterm is considered is less than 37 weeks.