

**Supplemental Material for Chapter 9 (Reproductive and
Developmental Effects) of the Integrated Science Assessment for
Particulate Matter**

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SUPPLEMENTAL TABLES FOR CHAPTER 9 (Reproductive and Developmental Effects)

Table S9-1: Epidemiologic Studies of Fertility and Maternal Health during Pregnancy

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|--|---|---|
| Short term exposures | | | |
| †{Seanan, 2015, 3012152@@author-year} Genk, Belgium February 2010 – March 2012 Cohort | ENVIRONAGE N = 247 mother-infant pairs | Spatiotemporal interpolation: kriging using land cover and monitor data Means: 15 – 18.7 | Placental gene expression, multiple gene models AKT cascade M1: -0.03 (-0.07, 0.0009) T1: -0.03 (-0.08, 0.02) T2: 0.02 (-0.03, 0.07) T3: -0.03 (-0.09, 0.02) SOS cascade M1: -0.1 (-0.2, -0.07) T1: -0.15 (-0.2, -0.08) T2: -0.05 (-0.2, 0.04) T3: -0.09 (-0.2, 0.02) PLCG cascade M1: -0.08 (-0.1, -0.03) T1: -0.1 (-0.2, -0.03) T2: 0.02 (-0.09, 0.1) T3: -0.09 (-0.2, 0.01) Other results reported as figures |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|-------------------------|---|---|
| †{Lee, 2011, 733688@@author- year@@author-year} Allegheny county, PA, U.S. 1999 – 2001 Cohort | N = 1084 pregnancies | Monitors Mean: 16.4 | C-RP concentration <8ng/mL v. >= 8ng/mL (RR) 8 day average: 1.17 (1.02, 1.35) 22 day average: 1.31 (1.05, 1.64) 29 day average: 1.26 (0.97, 1.63) lag 0: 0.99 (0.88, 1.11) lag 1: 1.05 (0.92, 1.21) lag 2: 1.11 (0.97, 1.27) lag 3: 1.02 (0.91, 1.14) lag 4: 1.07 (0.93, 1.23) lag 5: 1.11 (0.97, 1.26) lag 6: 1.03 (0.89, 1.20) lag 7: 1.03 (0.88, 1.21) Nonsmokers only 8 day average: 1.14 (0.91, 1.43) 22 day average: 1.52 (1.14, 2.05) 29 day average: 1.52 (1.05, 2.19) Nonsmokers, no environmental tobacco smoke 8 day average: 1.06 (0.70, 1.60) 22 day average: 1.20 (0.69, 2.08) 29 day average: 1.33 (0.73, 2.40) |
| †{Männistö, 2015, 2965904@@author- year@@author-year} United States 2002 – 2008 Cohort | N = 223, 502 deliveries | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Mean: 9.9 | Reported as figures, single day lags 0 to 7 |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|--------------------|---|--|
| †{Männistö, 2014, 2348724@@author- year@@author-year} United States 2002 – 2008 Cohort | N = 151,276 births | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Mean: NR | Higher blood pressure category at delivery (RR) Normotensive H0: 1.00 (1.00, 1.01) H1: 1.00 (1.00, 1.01) H2: 1.00 (1.00, 1.01) H3: 1.00 (1.00, 1.01) H4: 1.00 (1.00, 1.01) Gestational hypertensive H0: 1.03 (0.99, 1.07) H1: 1.03 (1.00, 1.07) H2: 1.04 (1.00, 1.08) H3: 1.03 (0.99, 1.07) H4: 1.03 (0.99, 1.07) Preeclampsia H0: 1.02 (0.99, 1.05) H1: 1.02 (0.99, 1.05) H2: 1.02 (0.99, 1.05) H3: 1.02 (0.99, 1.05) H4: 1.02 (0.99, 1.05) Chronic hypertensive H0: 0.97 (0.92, 1.02) H1: 0.97 (0.92, 1.02) H2: 0.97 (0.92, 1.02) H3: 0.97 (0.92, 1.02) H4: 0.99 (0.94, 1.04) Superimposed preeclampsia 1.07 (0.96, 1.20) 1.08 (0.97, 1.21) 1.09 (0.98, 1.21) 1.08 (0.97, 1.20) 1.08 (0.98, 1.19) |

Long term exposures

| | | | |
|---|---------------------------|------------------------------------|---|
| †{Nieuwenhuijsen, 2014, 2345882@@author- year@@author-year} Barcelona, Spain 2011 – 2012 Cross-sectional | N = 1061 census tracts | Land use regression Mean: 17.12 | Fertility (IRR, lower = worse) 0.97 (0.91, 1.03) |
|---|---------------------------|------------------------------------|---|

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|---|---|
| †{Slama, 2013, 2234208@@author-year@}@author-year} Czech Republic 1994 – 1999 Cohort | N = 1,916 couples | Central Site Monitor Mean: | Fecundability (FR) 1st month unprotected intercourse: 0.98 (0.93, 1.03) 30 days before initiation of unprotected intercourse: 0.93 (0.88, 0.98) 30 days before to 1 month after initiation of unprotected intercourse: 0.88 (0.81, 0.97) 1 month post-outcome: 1.02 (0.96, 1.08) |
| †{Mahalingaiah, 2014, 2334435@@author-year@}@author-year} United States 1993 – 2007 Cohort | Nurses Health Study N = 84,060 women | Spatiotemporal models Monthly average Mean: 15.4 | Endometriosis (OR) 2 year average lag: 0.97 (0.91, 1.05) 4 year average lag: 0.96 (0.89, 1.03) Cumulative average: 0.95 (0.89, 1.02) |
| †{Mahalingaiah, 2016, 3227444@@author-year@}@author-year} United States 1993 – 2007 Cohort | Nurses Health Study N = 36,294 | Spatiotemporal models Monthly average Mean: 14.5 | Infertility (OR) 2 years prior: 0.99 (0.93, 1.06) 4 years prior: 0.95 (0.88, 1.02) Cumulative from 1989: 1.02 (0.96, 1.10) |
| †{Hansen, 2009, 594438@@author-year} Wake County, NC; Shelby County, TX; Galveston County, TX, U.S. 2002 – 2004 Cohort | Healthy Men Study N = 228 presumed fertile men | Monitors Exposure over 90 days before sample Means: 10.9 - 14.2 | Sperm concentration (Δ millions/mL): 0.08 (-0.48, 0.65) Sperm count (Δ millions/sample): 0.31 (-0.25, 0.87) Percent normal morphology (Δ): 0.55 (-0.28, 1.37) Percent abnormal morphology (Δ): -0.29 (-0.72, 0.15) Percent abnormal head (Δ): 0.14 (-0.31, 0.58) Percent abnormal midsection (Δ): -0.63 (-1.28, 0.03) Percent abnormal tail (Δ): -0.60 (-1.23, 0.03) Percent cytoplasmic droplets (Δ): 2.37 (-0.04, 4.78) Percent chromomycin A3 staining (Δ): 0.28 (-0.33, 0.88) Percent sperm chromatin structure assay–DNA fragmentation index (Δ): -0.54 (-1.15, 0.08) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|--|---|--|
| †{Radwan, 2015, 3021139@@author-year} Lodz, Poland Cohort | Environmental factors and male infertility N = 327 men attending an infertility clinic | Monitor, nearest to zip code Exposure over 90 days before sample Mean: 34.52 | Log concentration (million/mL): -0.20 (- 2.60, 2.20) Motility (%): -17.90 (-39.50, 3.75) Sperm w/abnormal morphology: 167.10 (120.00, 214.20) Straight-line velocity (um/s): -3.30 (- 8.25, 34.90) Curvilinear velocity (um/s): 29.85 (- 4.05, 63.70) Linearity (%): 0.55 (-0.95, 2.05) Log follicle stimulating hormone (mIU/mL): 0.65 (-0.45, 1.80) Estradiol (pg/mL): -8.10 (-10.55, 26.70) Testosterone (ng/mL): -2.45 (-6.30, 1.35) Log DNA fragmentation index (%): 0.25 (-1.65, 1.20) High DNA stability (%) - immature cells: 1.80 (0.85, 2.75) |
| †{Hammoud, 2009, 192156@@author- year@@author-year} Salt Lake City, Utah, U.S. 2002 – 2007 Cohort | N = 1,699 semen analyses, 877 inseminations | Monitors Monthly average Mean: NR | Sperm motility (Δ % (p-value)) lag 0 months: 0.053 (0.606) lag 1 month: 0.1105 (0.278) lag 2 months: -0.1715 (0.093) lag 3 months: -0.2035 (0.039) lag 4 months: -0.0405 (0.69) Sperm concentration (Δ Mil/mL (p- value)) lag 0 months: -0.041 (0.68) lag 1 month: 0.174 (0.07) lag 2 months: -0.1425 (0.159) lag 3 months: 0.005 (0.958) lag 4 months: -0.0595 (0.535) Sperm Morphology (Δ % (p-value)) lag 0 months: 0.0075 (0.944) lag 1 month: 0.1665 (0.098) lag 2 months: -0.0295 (0.776) lag 3 months: 0.014 (0.894) lag 4 months: 0.0405 (0.693) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|-------------------------|---|--|
| †{Fleish, 2014, 2446292@@author-year} Boston, MA, U.S. 1999 – 2002 cohort | N = 2,093 women | Central site monitor, within 40km Exposure averaged over T2 Mean: 10.9 Spatio-temporal model using satellite data Exposure averaged over T2 Mean: 11.9 | Oral glucose challenge test/oral glucose tolerance test (OR) Central site: 1.51 (0.81, 2.75) Spatio-temporal model: 1.21 (0.65, 2.32) Impaired glucose tolerance (OR) Central site: 1.21 (0.65, 2.32) Spatio-temporal model: 2.37 (0.94, 6.01) Gestational diabetes mellitus (OR) Central site: 3.44 (1.30, 9.11) Spatio-temporal model: 0.54 (0.25, 1.25) |
| †{Hu, 2015, 2857917@@author-year} Florida, U.S. 2004 – 2005 cohort | N = 410,267 women | EPA's hierarchical bayesian space-time statistical model (fused CMAQ) Means: 9.74 – 10.03 | Gestational diabetes (OR) EP: 1.16 (1.11, 1.21) T1: 1.15 (1.10, 1.20) T2: 1.20 (1.13, 1.26) Adjusted for O3 EP: 1.11 (1.06, 1.16) T1: 1.02 (0.98, 1.07) T2: 1.10 (1.04, 1.16) |
| †{Robledo, 2015, 2826807@@author-year} United States 2002 – 2008 cohort | N = 219,952 pregnancies | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Median: 11.71 | Gestational diabetes (OR) 3 months preconception: 0.97 (0.94, 1.02) T1: 0.98 (0.94, 1.03) |
| †{Fleish, 2016, 3267796@@author-year} MA, U.S. 2003 – 2008 cohort | N = 159,373 women | Satellite-based spatiotemporal model, 1 km grid Mean: 10.4 | Gestational diabetes (OR) T1 Q1, 3.1-9.3: ref Q2, 9.3-10.4: 1.00 (0.93, 1.09) Q3, 10.4 - 11.5: 0.97 (0.89, 1.05) Q4, 11.5 - 17.1: 1.00 (0.92, 1.09) T2 Q1, 1.3 - 9.2: ref Q2, 9.2 - 10.4: 1.04 (0.96, 1.13) Q3, 10.4 - 11.6: 0.95 (0.88, 1.03) Q4, 11.6 - 19.3: 0.99 (0.91, 1.08) |
| †{Xu, 2014, 2234478@@author-year} Jacksonville, FL, U.S. 2004 – 2005 cohort | N = 22,041 women | Monitor, nearest within 20km Mean: 10.01 – 10.44 | Hypertensive disorders of pregnancy (OR) T1: 1.09 (0.99, 1.20) T2: 1.24 (1.11, 1.39) EP: 1.20 (1.07, 1.36) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|----------------------------------|--|--|
| †{Lee, 2012, 1258305@@author-year} Allegheny County, PA, U.S. 1997 – 2001 Cohort | N = 1,684 women | Space-time ordinary kriging, zip code centroid Mean: 18.1 | Blood pressure before 20 weeks compared to late pregnancy (Δ mmHg) Systolic: 0.53 (-0.87, 1.92) Diastolic: 0.50 (-0.54, 1.55) Non-smokers Systolic: 1.11 (-0.43, 2.63) Diastolic: 0.79 (-0.36, 1.93) |
| †{Lee, 2013, 1258306@@author-year} Pittsburgh, PA, U.S. 1997 – 2002 Cohort | N = 34,705 women | Space-time ordinary kriging, zip code centroid Mean: 15.6 | Preeclampsia (OR) T1: 1.19 (0.95, 1.51) Gestational hypertension (OR) T1: 1.14 (1.00, 1.30) |
| †{Dadvand, 2013, 2234487@@author-year} Barcelona, Spain 2000 – 2005 Cohort | N = 8,398 pregnancies, 103 cases | Land use regression Means: 16.5 – 17.3 | Preeclampsia (OR) EP: 1.31 (1.02, 1.69) T1: 1.18 (0.96, 1.45) T2: 1.08 (0.90, 1.30) T3: 1.33 (1.09, 1.61) Early onset preeclampsia, diagnosed at 20-34 weeks (OR) EP: 1.52 (0.94, 2.45) T1: 1.41 (0.95, 2.08) T2: 1.26 (0.88, 1.81) T3: 1.19 (0.80, 1.78) Late onset preeclampsia, diagnosed after 34 weeks (OR) EP: 1.18 (0.87, 1.59) T1: 1.09 (0.86, 1.40) T2: 1.03 (0.82, 1.28) T3: 1.27 (1.01, 1.61) |
| †{Dadvand, 2014, 2446248@@author-year} Barcelona, Spain 2003 – 2005 Cohort, hospital based | N = 3,182 women | Positive Matrix Factorization Mean: 32.5 | Preeclampsia (OR) EP: 0.63 (0.39, 1.03) PM2.5 from traffic related sources only, EP: 1.06 (0.44, 2.50) |
| †{Rudra, 2011, 732732@@author-year} Washington, U.S. 1996 – 2006 Cohort | N = 732,732 women | Land use regression Mean: 10.8 | Preeclampsia (OR) 7 months around conception: 1.22 (0.48, 3.11) |
| †{Jedrychowski, 2012, 2205584@@author-year} Krakow, Poland Cohort | N = 431 women | Personal monitor Over 2 days in the 2 nd trimester Mean: 33.6 | Blood pressure in 3 rd trimester (Δ mmHg), per 1-log unit increase in PM2.5 Systolic: 6.126 (0.610, 11.642) Diastolic: 4.083 (-0.019, 8.185) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|------------------------|--|---|
| †{Vinikoor-Imler, 2012, 1254457@@author-year} North Carolina, U.S. 2000 – 2003 Cohort | N = 222,775 women | Monitor Means: 22.2 – 22.4 | Hypertensive disorders of pregnancy (OR) EP: 1.26 (1.19, 1.37) |
| †{Wu, 2009, 190995@@author-year} LA and Orange Counties, CA, U.S. 1997 – 2006 Cohort | N = 81,186 | CALINE4 line-source dispersion model Mean: 1.82 | Preeclampsia (OR) EP: 1.47 (1.24, 1.68) |
| †{Wu, 2011, 758517@@author-year} LA and Orange Counties, CA, U.S. 1997 – 2006 Cohort | N = 81,186 | CALINE4 line-source dispersion model Mean: 1.82 Monitor Mean: 17.3 | Preeclampsia (OR) Monitor LA: 0.59 (0.31, 1.05) Orange: 0.90 (0.53, 1.54) CALINE4 LA: 1.47 (1.10, 2.01) Orange: 1.61 (1.22, 2.19) |
| †{Savitz, 2015, 2990723@@author-year} New York, NY, U.S. 2008 – 2010 Cohort | N = 268, 601 | Land use regression Mean: NR | Total hypertensive disorders (OR) T1: 0.96 (0.93, 1.00) T2: 0.95 (0.92, 0.99) Gestational hypertension (OR) T1: 0.98 (0.93, 1.05) T2: 0.94 (0.88, 1.00) Mild preeclampsia (OR) T1: 0.94 (0.88, 1.00) T2: 0.95 (0.89, 1.00) Severe preeclampsia/eclampsia T1: 0.97 (0.91, 1.05) T2: 0.98 (0.90, 1.05) |
| †{Mendola, 2016, 3223159@@author-year} United States 2002 - 2008 | N = 210,508 deliveries | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Mean: 11.8 | Preeclampsia (OR) Women with asthma preconception (90 days): 0.95 (0.86, 1.06) T1: 1.02 (0.93, 1.15) T2: 0.99 (0.91, 1.13) EP: 1.01 (0.93, 1.26) Women without asthma preconception (90 days): 0.97 (0.94, 1.02) T1: 1.03 (0.94, 1.04) T2: 1.02 (0.95, 1.04) EP: 1.04 (0.94, 1.12) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|---|---|
| †{Mobasher, 2013, 1519563@@author-year} Los Angeles County, CA, U.S. 1996 - 2008 | N = 298 women | Monitors Mean (SD): 17 (3.5) | Hypertensive disorders of pregnancy (OR) T1: 2.66 (1.53, 4.63) T2: 1.56 (0.96, 2.51) T3: 1.30 (0.82, 2.03) BMI < 30 T1: 4.66 (2.24, 9.72) T2: 1.49 (0.81, 2.70) T3: 1.19 (0.69, 2.08) BMI ≥ 30 T1: 0.79 (0.25, 2.48) T2: 1.87 (0.74, 4.71) T3: 1.27 (0.46, 3.42) |
| †{Seanan, 2015, 3012152@@author-year} ZOL, Genk, Belgium Feb 2010 - Mar 2012 Cohort | ENVIRONAGE N = 247 mother-infant pairs | Spatiotemporal interpolation model (kriging, using land cover and monitor data) Means: 15 – 18.7 | AKT cascade (BDNF, AKT1, AKT2, AKT3) M1: -0.03 (-0.07, 0.00) T1: -0.03 (-0.08, 0.02) T2: 0.02 (-0.03, 0.07) T3: -0.03 (-0.09, 0.02) SOS cascade (BDNF, SOS1, SOS2, SYN1) M1: -0.10 (-0.20, -0.07) T1: -0.15 (-0.20, -0.08) T2: -0.05 (-0.20, 0.04) T3: -0.09 (-0.20, 0.02) PLCG cascade (BDNF, PLCG1, PLCG2) M1: -0.08 (-0.10, -0.03) T1: -0.10 (-0.20, -0.03) T2: 0.02 (-0.09, 0.10) T3: -0.09 (-0.20, 0.01) |
| †{Saenan, 2016, 3425113@@author-year} ZOL, Genk, Belgium 2010 – 2013 Cohort | ENVIRONAGE N = 330 | Spatiotemporal interpolation model (using land cover, monitor, and dispersion data) Mean: 16.1 | Placental 3-NTp, biomarker of oxidative stress (% change) EP: 50.00 (19.86, 85.71) T1: 16.48 (2.78, 33.30) T2: 26.55 (8.31, 49.12) T3: 7.02 (-5.00, 21.97) |
| †{Nachman, 2016, 3352474@@author-year} Boston, MA, U.S. 1999 – 2012 Cohort | Boston Birth Cohort N = 5,059 mothers | Monitor, nearest no distance limit | Intrauterine inflammation (OR) preconception (90 days): 1.07 (0.96, 1.20) T1: 1.42 (1.26, 1.60) T2: 1.45 (1.29, 1.64) T3: 1.12 (1.00, 1.26) EP: 1.68 (1.47, 1.92) Last month: 1.15 (1.04, 1.26) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|--|--|--|
| †{Lavigne, 2016, 3360443@@author-year} Canada 2008 – 2011 Cohort | MIREC Study N = 1,257 mother-infant pairs | Land use regression, satellite and monitor based Monthly average Exposures averaged over entire pregnancy Mean: 8.3 | Fetal leptin (% change) 17.19 (1.56, 32.81) Fetal adiponectin (% change) 17.19 (6.25, 26.56) |
| †{Janssen, 2016, 3452660@@author-year} Limburg, Belgium 2010 – 2014 Cohort | ENVIRONAGE N = 431 newborns | Spatiotemporal interpolation model (using land cover, monitor, and dispersion data) Mean: 16 | Fetal thyroid stimulating hormone (% change) T3: -7.07 (-13.29, -0.06) Fetal FT4/FT3 ratio (% change) T3: -38.23 (-55.85, -20.61) |
| †{Herr, 2010, 689866@@author-year} Czech Republic 1994 – 1999 Cohort | N = 1,397 mother-infant pairs | Monitor Mean: 26.9 | Umbilical cord CD3+ (% change) M1: 0.50 (0.14, 0.84) M7: -0.50 (-0.18, -0.84) Umbilical cord CD4+ (% change) M1: 0.44 (0.14, 0.74) M7: -0.40 (-0.12, -0.68) |

CMAQ community multiscale air quality modeling system, C-RP: C-reactive protein, EP: entire pregnancy, FR: fecundity ratio M1: 1st month of pregnancy, IRR: incidence rate ratio, M7: 7th month of pregnancy, OR: odds ratio, RR: risk or rate ratio, T1: 1st trimester of pregnancy, T2: 2nd trimester of pregnancy, T3: 3rd trimester of pregnancy.

^aAll estimates reported per 5µg increase in PM_{2.5} unless otherwise stated

†Studies published since the 2009 Integrated Science Assessment for Particulate Matter.

Table S9-2: Epidemiologic Studies of Fetal Growth

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|---|---|--|
| {Jedrychowski, 2017, 3603592@@author-year} Krakow, Poland Follow-up: 2000-2004 Prospective Pregnancy Cohort | 455 healthy women (18-35 years) who delivered between 34 and 42 weeks | Personal monitor worn for 2 days during second trimester | Birth Length (cm) -0.11 (p=0.017) per 1 StDev in ln-transformed PM2.5 concentration Head Circumference (cm) -0.11 (p=0.014) per 1 StDev in ln-transformed PM2.5 concentration |
| {Bell, 2010, 647226@@author-year} CT and MA 2000-2004 | 76,788 births recorded by the National Center for Health Statistics, with a gestation period between 37 and 44 weeks | Measurements from PM2.5 regulatory monitors during the pregnancy | BW (change in grams) Total pregnancy: -8 (-25, 6) 1 st trimester: -3 (-17, 14) 2 nd trimester: 0 (-14, 14) 3 rd trimester: -6 (-22, 8) Percent Increase, Risk of Small-at-term Birth: 19 (-3, 47) |
| {Darrow, 2011, 723764@@author-year} Atlanta, GA 1994-2004 | 406,267 births with a gestation period of at least 37 weeks in the five central counties of the Atlanta metropolitan area | Modeled data from PM2.5 monitor measurements over the course of the pregnancy | BW (change in grams) First month: 0 (-7.4, 7.4) Third trimester: -10.8 (-24.5, 3.0) |
| {Erickson, 2016, 3258195@@author-year} British Columbia, Canada 2001-2006 | 231,929 live and still-born birth records | National PM2.5 land-use regression model | BW (modeled effect on birth weight) $\beta = -239 (-265, -213)$ |
| †{Fleisch, 2015, 2533478@@author-year} Boston, MA Follow-up: NR Pregnancy Cohort | 2,115 singleton live births to mothers enrolled in Project Viva cohort study | Satellite-based predictions from modeling approach (see {Kloog, 2011, 1056437}) averaged over third trimester | Birth Weight for Gestational Age (BWGA) z-score; Third Trimester Q1: 1.00 (referent) Q2: -0.02 (-0.14, 0.10) Q3: 0.03 (-0.09, 0.15) Q4: -0.08 (-0.2, 0.04) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|--|---|--|
| {Geer, 2012, 1525340@@author-year} Texas 1998-2004 | 1,548,904 birth records with gestational period between 47 and 44 weeks | Average PM2.5 monitor measurements by county of residence | BW (change in grams) Gestational period: 24.9 (5.8, 44.1) |
| {Gehring, 2014, 2342497@@author-year} Vancouver, Canada 1999-2002 | 68,238 singleton births | PM2.5 land-use regression model | BW (change in grams) Entire pregnancy: -31 (-51, -11) PTB (OR) Moderately PTB: 1.00 (0.82, 1.34) Very PTB: 1.97 (1.00, 4.05) |
| {Gehring, 2011, 677057@@author-year} Netherlands 1996-1997 Pregnancy Cohort | 3,853 births in the prospective Prevention and Incidence of Asthma and Mite Allergy (PIAMA) cohort | PM2.5 land-use regression model | BW (change in grams) Entire pregnancy: 65.2 (-15.4, 145.9) 1 st trimester: 22.4 (-8.7, 53.4) Final month: -26.0 (-66.0, 14.0) PTB (OR) Entire pregnancy: 1.54 (0.67, 3.59) 1 st trimester: 0.97 (0.69, 1.39) Final month: 1.12 (0.72, 1.76) |
| {Gray, 2010, 1255022@@author-year} North Carolina 2000-2002 | 350,754 births from mothers between 15 and 44 years of age, with between 32 and 44 weeks of gestation and with no congenital anomalies | County-level measures from EPA Air Quality System PM2.5 monitors | BW (change in grams) Entire pregnancy: 28.8 (14.4, 42.5) Third trimester: 33.6 (20.7-46.5) (Other results not reported) |
| {Hannam, 2014, 2349678@@author-year} Northwest England 2004-2008 | 203,562 births in the NW Perinatal Survey Unit cohort | Spatio-temporal (S-T) model, Nearest stationary monitor technique (NSTAT) | BW (change in grams) S-T: 11 (-24, 48) NSTAT: 18, (-302, 336) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|---|--|--|
| {Hyder, 2014, 2337044@@author-year} CT & MA, US Follow-up: 2000-2006 Birth Cohort Study | 662,921 births, 2% term LBW, 10% SGA | Weekly averages from closest ground monitors within 50 km of maternal residence Satellite-based predictions from calibration and modeling approach (see {Lee, 2011, 3198426; Lee, 2012, 2093829}) | Term BW; Entire Pregnancy Monitor: -12.9 (-16.4, -9.5) Satellite 1: -32.6 (-42.5, -22.4) Satellite 2: -93.4 (-47.7, -30.9) |
| {Jedrychowski, 2010, 382241@@author-year} NYC, NY and Krakow, Poland 2001-2004 | 481 women who gave birth after 36 weeks of gestation | Personal monitor worn for 2 days during second trimester | BW -1.01 (-83.19, 81.17) for PM _{2.5} exposure in second tertile (27.0 - 46.29 µg/m ³) relative to first tertile -97.02 (-185.67, -8.37) for PM _{2.5} exposure in third tertile (> 46.29 µg/m ³) relative to first tertile |
| {Jedrychowski, 2017, 3603592@@author-year} Krakow, Poland Follow-up: 2000-2004 Prospective Pregnancy Cohort | 455 healthy women (18-35 years) who delivered between 34 and 42 weeks | Personal monitor worn for 2 days during second trimester | Term BW -0.10 g (p=0.023) per 1 StDev in ln-transformed PM _{2.5} concentration |
| {Keller, 2017, 3604156@@author-year} Georgia, U.S. Follow-up: 2002-2005 Birth Cohort Study | 403,881 births statewide; 180,440 births in counties with PM _{2.5} monitor | Bootstrap-based exposure measurement error correction methods applied to spatiotemporal predictions (1 km grid cells) averaged over trimesters | Term BW Residing in county with PM _{2.5} monitor T1: -7.5 (-15.5, 0.5) T2: -8.0 (-16.0, 0.0) T3: -12.0 (-19.5, -4.0) Bootstrap correction for exposure measurement error T1: -7.5 (-17.5, 0.5) T2: -8.0 (-16.5, 0.0) T3: -12.5 (-21.0, -4.0) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|---|--|
| †{Kloog, 2012, 1254456@@author-year} Massachusetts, US Follow-up: 2000-2008 Birth Cohort Study | 634,844 singleton live births from MA Birth Registry | Satellite-based predictions from modeling approach (see {Kloog, 2011, 1056437; Lee, 2011, 3198426}) | Term BW Entire Pregnancy: -4.40 (-5.16, -2.22) 30 days before birth: -4.6 (-7.5, -1.65) 90 days before birth: -7.9 (-10.55, -3.03) |
| †{Lakshmanan, 2015, 3014420@@author-year} Boston, MA Follow-Up: 2002-2009 Pregnancy Cohort Study | 955 singleton births to mothers enrolled in Asthma Coalition on Community, Environment, and Social Stress (ACCESS) cohort | Satellite-based predictions from modeling approach (see {Kloog, 2011, 1056437}) averaged over entire pregnancy cohort | Birth Weight for Gestational Age (BWGA) z-score; Entire Pregnancy 0.16 (-0.33, 0.63) |
| †{Laurent, 2013, 1520605@@author-year} Los Angeles, CA 1997-2006 Birth Cohort Study | 61,623 term births from network of four hospitals in LA and Orange counties | Ground monitors (closest monitor), CALINE 4 dispersion model; averaged for each month | Ground Monitor Birth Weight Entire Pregnancy: 26.83 (21.56, 32.11) CALINE Birth Weight Entire Pregnancy: 21.8 (15.78, 35.18) |
| {Madsen, 2010, 625022@@author-year} Oslo, Norway 1999-2002 | 25,229 singleton birth records with weight of at least 1000 grams | EPISODE dispersion model | BW (change in grams relative to lowest quartile exposure, < 9.7 µg/m³) Q2 (9.1-11.5 µg/m ³): 0.8 (-14.5, 16.0) Q3 (11.6-14.1 µg/m ³): 16.3 (0.8, 31.7) Q4 (> 14.1 µg/m ³): 13.6 (-2.4, 29.5) |
| {Morello-Frosch, 2010, 670076@@author-year} California 1996-2006 | 3,545,177 singleton births from tracts or ZIP codes within 10 km of a monitor | Monitors from either EPA Air Quality System of CalAIRS | BW (change in grams) Within 3 km of monitor: -9.2 (-12.5, -5.9) 5 km: -11.4 (-13.5, -9.3) 10 km: -12.8 (-14.3, -11.3) |
| {Parker, 2008, 156846@@author-year} United States 2001-2003 | 401,273 births recorded by the national Center for Health Statistics | County averages of monitors from EPA Air Quality System | BW (change in grams) Unadjusted: 19.4 (9.8, 29.0) Fully adjusted: 4.6 (-6.1, 15.3) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|--|--|
| {Pedersen, 2013, 2230821@@author-year} 12 European countries 1994-2011 | 74,178 births in the European Study of Cohorts for Air Pollution Effects (ESCAPE) | Land-use regression models | BW [Tom—seems like only LBW reported?] |
| {Slama, 2010, 1256660@@author-year} Germany 1997-1999 | 992 genotyped singleton births in the LISA cohort | Land-use regression model | BW (change in grams, above median exposure compared to below median exposure, 14.4 µg/m³) -22 (-99, 55) |
| †{Stieb, 2015, 3010154@@author-year} Multicity, Canada Follow-up: 1999-2008 Birth Cohort Study | 3 million singleton live births; 1.57% term LBW and 8.31% SGA | Hybrid of ground monitors, LUR and remote sensing (satellite images) described in {Beckerman, 2013, 2331242@@author-year} | Term BW; Entire Pregnancy -20.5 (-24.7, -16.4) grams |
| {Tu, 2016, 3359743@@author-year} Georgia 2000 | 105,818 singleton full-term births in the Georgia Vital Records Office | EPA Fused Air Quality Predictions Surface model | BW [Tom—not sure how you want to present this study's results] |
| {Vinikoor-Imler, 2014, 2369649@@author-year} North Carolina 2003-2005 | 297,043 births in North Carolina State Center for Health Statistics records | Bayesian model from EPA Air Quality System monitors and CMAQ model | BW (change in grams per IQR = 3.5 µg/m³) Trimester 1: 12.66 (4.57, 20.71) Trimester 2: 0.94 (-7.00, 8.89) Trimester 3: 6.11 (-1.66, 13.86) |
| †{Brauer, 2008, 156292@@author-year} Vancouver, BC Follow-up: 1999-2002 Birth Cohort Study | 70,249 live births in study area with data on residential history | IDW based on ground-monitors (n=7) assigned to postal codes LUR (R ² =0.52), cross-validation revealed poor performance of PM _{2.5} LUR model | Term LBW; Entire Pregnancy IDW: 0.91 (0.68, 1.25) LUR: 1.10 (0.97, 1.25) |
| {Brown, 2015, 3014233@@author-year} New York, USA 2001-2006 | 480,430 births; 9,782 term LBW | Hierarchical Bayesian spatio-temporal model incorporating CMAQ data | TLBW (OR relative to Q1 exposure) First trimester, Q2: 0.97 (0.91, 1.03) First trimester, Q3: 0.94 (0.88, 1.00) First trimester, Q4: 0.97 (0.91, 1.04) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|--|--|---|
| | | | Second trimester, Q2: 0.97 (0.91, 1.04) |
| | | | Second trimester, Q3: 0.96 (0.90, 1.02) |
| | | | Second trimester, Q4: 0.99 (0.93, 1.06) |
| | | | Third trimester, Q2: 0.97 (0.91, 1.03) |
| | | | Third trimester, Q3: 0.94 (0.88, 1.00) |
| | | | Third trimester, Q4: 0.97 (0.93, 1.06) |
| | | | Entire pregnancy, Q2: 0.95 (0.89, 1.01) |
| | | | Entire pregnancy, Q3: 0.92 (0.86, 0.98) |
| | | | Entire pregnancy, Q4: 0.97 (0.91, 1.04) |
| {Cândido da Silva, 2014, 2535402@@author-year} | 6,147 full-term singleton births | Model incorporating emissions from Amazonian biomass burning | LBW (OR relative to Q1 exposure) |
| Mato Grosso, Brazil | | | First trimester, Q2: 0.95 (0.68, 1.33) |
| 2004-2005 | | | First trimester, Q3: 1.31 (0.92, 1.88) |
| | | | First trimester, Q4: 1.02 (0.74, 1.42) |
| | | | Second trimester, Q2: 1.06 (0.76, 1.47) |
| | | | Second trimester, Q3: 1.22 (0.87, 1.71) |
| | | | Second trimester, Q4: 1.51 (1.04, 2.17) |
| | | | Third trimester, Q2: 1.01 (0.73, 1.38) |
| | | | Third trimester, Q3: 1.18 (0.83, 1.70) |
| | | | Third trimester, Q4: 1.50 (1.06, 2.15) |
| | | | Entire pregnancy, Q2: 0.95 (0.69, 1.31) |
| | | | Entire pregnancy, Q3: 1.20 (0.85, 1.69) |
| | | | Entire pregnancy, Q4: 1.33 (0.92, 1.90) |
| {Dadvand, 2013, 1464494@@author-year} | Approximately 3 million births total in 14 centers | Varying by study | LBW (OR) |
| International meta-analysis in 9 countries—PM2.5 data available for USA, Netherlands, Canada | | | Adjusted for maternal SES: 1.10 (1.03, 1.18) |
| | | | + Center-specific covariates: 1.04 (0.99, 1.09) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|--|---|
| 1962-2006 | | | |
| {Dadvand, 2014, 2343622@@author-year} | 6,438 singleton term births | Land-use regression models at maternal residence | LBW (OR) Entire pregnancy (IQR = 3.1 µg/m ³): 1.66 (0.94, 2.89) First trimester (IQR = 3.7 µg/m ³): 1.20 (0.71, 1.99) Second trimester (IQR = 3.7 µg/m ³): 1.60 (0.92, 2.73) Third trimester (IQR = 3.6 µg/m ³): 1.82 (1.09, 3.03) |
| Barcelona, Spain | | | |
| 2001-2005 | | | |
| {Ebisu, 2012, 1291204@@author-year} | 1,207,800 births in CT, DE, MD, MA, NH, NJ, NY, PA, RI, VT, VA, WV, and DC | County averages from monitors | LBW (Percent risk per IQR = 2.71 µg/m³) All data: 8.1 (-0.7, 17.7) First births only: 11.8 (-2.6, 26.9) |
| Northeastern and mid-Atlantic United States | | | |
| 2000-2007 | | | |
| {Fleischer, 2014, 2696137@@author-year} | 192,900 live births in the WHO Global Survey on Maternal and Perinatal Health | Long-term averages from remote sensing data | LBW (OR) 0.99 (0.96, 1.01) PTB (OR) 0.96 (0.90, 1.02) |
| 22 countries in Africa, Asia, and Latin America | | | |
| 2004-2008 | | | |
| {Gray, 2014, 2369616@@author-year} | 457,642 births to Nonhispanic White, Nonhispanic Black, and Hispanic women | Bayesian downscaling fusion model | BW (change in grams) -13.61 (-14.52, -12.74) LBW (OR) 1.09 (0.96, 1.19) SGA (OR) 1.16 (1.10, 1.28) PTB (OR) 1.04 (0.96, 1.09) |
| North Carolina | | | |
| 2002-2006 | | | |
| †{Ha, 2014, 2535539@@author-year} | 423,719 singleton live births; 2.4% term LBW | HBM CMAQ predictions for 2003-2005 at maternal residence | Term LBW Entire pregnancy: 1.04 (0.97, 1.11) T1: 1.01 (0.96, 1.07) T2: 1.07 (1.01, 1.12) |
| Florida, US | | | |
| Follow-up: 2004-2005 | | | |
| Birth Cohort Study | | | |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|---|---|---|
| | | | T3: 1.01 (0.96, 1.06) |
| †{Ha, 2017, 3602821@@author-year} | 220,572 births, 11.2% SGA; 2.2% term LBW | Population-weighted CMAQ predictions corrected using IDW to local monitors | Term LBW Entire pregnancy: 1.10 (0.97, 1.26) T1: 1.08 (0.99, 1.17) T2: 1.01 (0.93, 1.10) T3: 0.93 (0.86, 1.01) |
| Multi-city, U.S. Follow-up: 2002-2008 Birth Cohort Study | | | |
| {Harris, 2014, 2534841@@author-year} | 1,374,875 births in CT, ME, MN, NJ, NY, UT, WI | Community Multi-scale Air Quality (CMAQ) model | LBW (OR) Full pregnancy: 1.34 (1.24, 1.44) T1: 1.20 (1.14, 1.24) T2: 1.13 (1.07, 1.18) T3: 1.09 (1.05, 1.15) |
| 7 states in the United States 2001-2004 | | | |
| †{Hyder, 2014, 2337044@@author-year} | 662,921 births, 2% term LBW, 10% SGA | Weekly averages from closest ground monitors within 50 km of maternal residence | Term LBW; Entire Pregnancy Monitor: 1.02 (0.96, 1.08) Satellite 1: 1.13 (0.94, 1.36) Satellite 2: 1.17 (1.02, 1.36) |
| CT & MA, US Follow-up: 2000-2006 Birth Cohort Study | | Satellite-based predictions from calibration and modeling approach (see {Lee, 2011, 3198426; Lee, 2012, 2093829}) | |
| {Laurent, 2014, 2347637@@author-year} | 960,945 singleton births between 260 and 208 estimated days of gestation | Bayesian model using California Air Resources Board monitors | LBW (OR) 1.03 (1.02, 1.05) |
| Los Angeles County, CA 2001-2008 | | | |
| †{Laurent, 2013, 1520605@@author-year} | 61,623 term births from network of four hospitals in LA and Orange counties | Ground monitors (closest monitor), CALINE 4 dispersion model; averaged for each month | Ground Monitor Term LBW Entire Pregnancy: 0.93 (0.84, 1.02) |
| Los Angeles, CA 1997-2006 Birth Cohort Study | | | |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|--|---|--|
| | | | CALINE |
| | | | Birth Weight |
| | | | Entire Pregnancy: 21.8 (15.78, 35.18) |
| {Lavinge, 2016, 3223161@@author-year} | 818,400 singleton live births | Satellite-based estimates at maternal postal code | LBW (OR) 0.82 (0.69, 0.96) |
| Ontario, Canada | | | SGA (OR) 0.82 (0.76, 0.88) |
| 2005-2012 | | | PTB (OR) 1.22 (1.13, 1.31) |
| {Madsen, 2010, 625022@@author-year} | 25,229 singleton birth records with weight of at least 1000 grams | EPISODE dispersion model | LBW (OR relative to lowest quartile exposure, < 9.7 µg/m³) Q2 (9.7-11.5 µg/m ³): 0.9 (0.7, 1.2) Q3 (11.6-14.1 µg/m ³): 0.9 (0.6, 1.2) Q4 (> 14.1 µg/m ³): 0.9 (0.5, 1.0) |
| Oslo, Norway | | | SGA (OR relative to lowest quartile exposure, < 9.7 µg/m³) Q2 (9.7-11.5 µg/m ³): 1.0 (0.9, 1.1) Q3 (11.6-14.1 µg/m ³): 1.0 (0.8, 1.1) Q4 (> 14.1 µg/m ³): 0.9 (0.8, 1.0) |
| {Morello-Frosch, 2010, 670076@@author-year} | 3,545,177 singleton births from tracts or ZIP codes within 10 km of a monitor | Monitors from either EPA Air Quality System of CalAIRS | LBW (OR) Within 3 km of monitor: 1.04 (0.99, 1.09) 5 km: 1.05 (1.02, 1.08) 10 km: 1.04 (1.02, 1.07) |
| California | | | |
| 1996-2006 | | | |
| {Parker, 2008, 156846@@author-year} | 401,273 births recorded by the national Center for Health Statistics | County averages of monitors from EPA Air Quality System | LBW (OR) 1.00 (0.91, 1.10) |
| United States | | | |
| 2001-2003 | | | |
| {Pedersen, 2013, 2230821@@author- year} | 74,178 births in the European Study of Cohorts for Air | Land-use regression models | LBW (OR) All: 1.18 (1.06, 1.33) |
| 12 European countries | | | |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|---|--|
| 1994-2011 | Pollution Effects (ESCAPE) | | Mothers exposed to < 15 µg/m ³ : 1.79 (1.29, 2.48) Mothers exposed to < 20 µg/m ³ : 1.41 (1.20, 1.65) Mothers exposed to < 25 µg/m ³ : 1.21 (1.06, 1.38) |
| †{Salihu, 2012, 2572094@@author-year} Hillsborough County, FL Follow-up: 200-2007 Birth Cohort Study | 103,961 singleton live births; 6.4% LBW and 8.4% SGA | 6-day concentrations from 14 ground monitors; maternal residential ZIP code centroid linked to nearest monitor, based on centroid of ZIP code in which monitor was located; exposure dichotomized at median | ORs for exposure above median compared to below median LBW; Entire Pregnancy 1.07 (1.01, 1.12) Very LBW; Entire Pregnancy 1.14 (1.01, 1.29) |
| †{Stieb, 2015, 3010154@@author-year} Multicity, Canada Follow-up: 1999-2008 Birth Cohort Study | 3 million singleton live births; 1.57% term LBW and 8.31% SGA | Hybrid of ground monitors, LUR and remote sensing (satellite images) described in {Beckerman, 2013, 2331242@@author-year} | Term LBW; Entire Pregnancy 1.01 (0.94, 1.08) |
| {Trasande, 2013, 1521270@@author-year} United States 2000, 2003, 2006 | 222,359 births in the Kids Inpatient Database (KID) | EPA AIRS monitors within 10 miles of hospital of birth | LBW (OR) 2.59 (1.79, 3.71) PTB (OR per IQR = 1 µg/m³) 0.74 (0.66, 0.82) |
| {Vinikoor-Imler, 2014, 2369649@@author-year} North Carolina 2003-2005 | 297,043 births in North Carolina State Center for Health Statistics records | Bayesian model from EPA Air Quality System monitors and CMAQ model | LBW (OR) Trimester 1: 0.84 (0.76, 0.94) Trimester 2: 0.86 (0.79, 0.97) Trimester 3: 1.03 (0.92, 1.18) SGA (OR) Trimester 1: 0.89 (0.84, 0.94) Trimester 2: 0.92 (0.86, 0.94) Trimester 3: 0.92 (0.86, 0.97) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|--|--|
| †{Brauer, 2008, 156292@@author-year} Vancouver, BC Follow-up: 1999-2002 Birth Cohort Study | 70,249 live births in study area with data on residential history | IDW based on ground-monitors (n=7) assigned to postal codes LUR (R ² =0.52), cross-validation revealed poor performance of PM _{2.5} LUR model | SGA; Entire pregnancy IDW: 1.09 (0.91, 1.25) LUR: 1.07 (1.00, 1.10) |
| †{Ha, 2017, 3602821@@author-year} Multi-city, U.S. Follow-up: 2002-2008 Birth Cohort Study | 220,572 births, 11.2% SGA; 2.2% term LBW | Population-weighted CMAQ predictions corrected using IDW to local monitors | SGA Entire pregnancy: 1.01 (0.96, 1.07) T1: 1.00 (0.97, 1.04) T2: 1.02 (0.99, 1.06) T3: 1.00 (0.97, 1.03) |
| {Hannam, 2014, 2349678@@author-year} Northwest England 2004-2008 | 203,562 births in the NW Perinatal Survey Unit cohort | Spatio-temporal (S-T) model, Nearest stationary monitor technique (NSTAT) | SGA (OR) S-T: 1.09 (0.85, 1.41) NSTAT: 3.04 (1.32, 7.11) PTB (OR) S-T: 0.96 (0.70, 1.28) NSTAT: 0.15 (0.04, 0.69) |
| †{Hyder, 2014, 2337044@@author-year} CT & MA, US Follow-up: 2000-2006 Birth Cohort Study | 662,921 births, 2% term LBW, 10% SGA | Weekly averages from closest ground monitors within 50 km of maternal residence Satellite-based predictions from calibration and modeling approach (see {Lee, 2011, 3198426; Lee, 2012, 2093829}) | SGA; Entire Pregnancy Monitor: 1.06 (1.02, 1.08) Satellite 1: 1.13 (1.06, 1.22) Satellite 2: 1.17 (1.08, 1.24) |
| {Lee, 2013, 1258306@@author-year} Allegheny County, PA | 34,705 deliveries at Magee-Women's Hospital in Pittsburgh, PA | Model using EPA and Allegheny County Health Department monitors | SGA (OR) Overall: 1.08 (0.86, 1.33) Mother smoked during pregnancy: 0.98 (0.73, 1.33) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---------------------------------------|--|---|---|
| 1997-2002 | | | Mothers did not smoke: 1.03 (0.79, 1.33) |
| {Rich, 2009, 180122@@author-year} | 178,198 birth certificates and maternal/newborn hospital discharge summaries | Measurement from closest PM2.5 monitor to maternal residence (excluded if >10 km away) | SGA (Percent change in risk) T1: 11.3 (1.3, 21.8) T2: -4.5 (-14.0, 5.5) T3: 10.3 (0.8, 20.0) |
| New Jersey | | | VSGA (Percent change in risk) T1: 6.5 (-11.0, 25.0) T2: 0.5 (-16.8, 18.8) T3: 10.5 (-6.0, 28.0) |
| 1999-2003 | | | |
| †{Salihu, 2012, 2572094@@author-year} | 103,961 singleton live births; 6.4% LBW and 8.4% SGA | 6-day concentrations from 14 ground monitors; maternal residential ZIP code centroid linked to nearest monitor, based on centroid of ZIP code in which monitor was located; exposure dichotomized at median | ORs for exposure above median compared to below median SGA; Entire pregnancy 1.06 (1.01, 1.11) |
| Hillsborough County, FL | | | |
| Follow-up: 200-2007 | | | |
| Birth Cohort Study | | | |
| †{Stieb, 2015, 3010154@@author-year} | 3 million singleton live births; 1.57% term LBW and 8.31% SGA | Hybrid of ground monitors, LUR and remote sensing (satellite images) described in {Beckerman, 2013, 2331242@@author-year} | SGA; Entire pregnancy 1.04 (1.01, 1.07) |
| Multicity, Canada | | | |
| Follow-up: 1999-2008 | | | |
| Birth Cohort Study | | | |

CMAQ community multiscale air quality modeling system, C-RP: C-reactive protein, EP: entire pregnancy, FR: fecundity ratio M1: 1st month of pregnancy, IRR: incidence rate ratio, M7: 7th month of pregnancy, OR: odds ratio, RR: risk or rate ratio, T1: 1st trimester of pregnancy, T2: 2nd trimester of pregnancy, T3: 3rd trimester of pregnancy.

^aAll estimates reported per 5µg increase in PM_{2.5} unless otherwise stated

†Studies published since the 2009 Integrated Science Assessment for Particulate Matter.

Table S9-3: Studies of Preterm Birth and Premature Rupture of Membranes

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|-------------------------------|--|---|
| Short term exposure | | | |
| †{Darrow, 2009, 195818 @@author-year} Atlanta, GA, U.S. 1994 – 2004 Time-series | N = 1994 days, 476,789 births | Monitors, daily population weighted spatial averages from 11 monitors Means: 16.4 – 16.5 | Preterm birth (RR) 1 week lag: 0.98 (0.97, 1.00) Within 4 miles of monitor 1 week lag: 1.00 (0.97, 1.02) |
| †{Rappazzo, 2014, 2369665 @@author-year} PA, OH, NJ, U.S. 2000 – 2005 Cohort | N = 1,940,213 | Fused CMAQ model, northeastern U.S. specific Exposures over each week of gestation Mean: 14.46 | Reported as figures |
| †{Warren, 2012, 1668664 @@author-year} Texas, U.S. 2002 - 2004 Cohort | NR | Monitors CMAQ Exposures over each week of gestation Mean: NR | Reported as figures |
| †{Symanski, 2014, 2541828 @@author-year} Harris County, Texas, U.S. 2005 – 2007 Cohort | N = 171, 923 | Monitors County average Mean: NR | Severe preterm birth (<28 weeks) weeks 1-4: 1.37 (1.15, 1.64) weeks 5-8: 0.95 (0.77, 1.15) weeks 9-12: 1.13 (0.93, 1.37) weeks 13-16: 0.84 (0.70, 1.01) weeks 17-20: 1.30 (1.07, 1.58) Moderately preterm birth (29-32 weeks) weeks 1-4: 1.38 (1.20, 1.59) weeks 5-8: 1.04 (0.88, 1.23) weeks 9-12: 1.28 (1.09, 1.51) weeks 13-16: 0.98 (0.84, 1.15) weeks 17-20: 0.96 (0.82, 1.13) weeks 21-24: 0.94 (0.80, 1.10) weeks 25-28: 1.39 (1.20, 1.61) Mildly preterm birth (33-36 weeks) weeks 1-4: 1.08 (1.02, 1.13) weeks 5-8: 1.04 (0.98, 1.10) weeks 9-12: 1.12 (1.06, 1.05) weeks 13-16: 0.98 (0.93, 1.03) weeks 17-20: 1.08 (1.01, 1.14) weeks 21-24: 0.91 (0.86, 0.96) weeks 25-28: 1.05 (0.99, 1.11) weeks 29-32: 1.14 (1.08, 1.21) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|------------------|--|--|
| †{Arroyo, 2016, 3063024 @@author-year} Madrid, Spain 2001 – 2009 Time series | N = 3,287 births | Monitors Single day lags Mean: 17.1 | Preterm birth per IQR increase (NR) Lag1: 1.04 (1.00, 1.07) |
| †{Arroyo, 2015, 3425187 @@author-year} Madrid, Spain 2004-2009 Time series | N = 314 weeks | Monitors Exposure at each week of pregnancy Mean: 17.1 | Preterm birth, only statistically significant lags reported week 17 (lag 20): 1.01 (1.01, 1.02) |
| †{Wallace, 2016,3223972} United States 2002 – 2008 Cohort | N = 223,375 | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Exposures lagged before hour of admission for delivery Mean: 11.9 | Preterm premature rupture of membranes Adjusted for all pollutants lag 0 hrs: 1.04 (1.00, 1.07) lag 1 hr: 1.04 (1.00, 1.07) lag 2 hrs: 1.03 (1.00, 1.07) lag 3 hrs: 1.03 (1.00, 1.07) lag 4 hrs: 1.03 (1.00, 1.06) |
| Long term exposure | | | |
| {Braucher, 2008, 156292 @@author-year} Vancouver, British Columbia, Canada 1999 – 2002 Cohort | N = 70,249 | Inverse distance weighing (IDW), 3 closest monitors within 50km Monthly 5.1 Land use regression (LUR) Monthly 4.0 | Preterm births (PTB) < 37 weeks EP: 1.34 (1.05, 1.69) Preterm births (PTB) < 30 weeks IDW: EP: 1.84 (0.66, 5.19) LUR: EP: 1.40 (0.90, 2.10) |
| †{Chang, 2013, 2082925 @@author-year} Mecklenburg County, North Carolina 2001 – 2005 Time-to-event | N = 55,647 | Model, EPA's monitor corrected CMAQ Mean: 15.5 | Preterm birth Cumulative pregnancy: 1.27 (1.07, 1.49) 4 week lag: 1.03 (0.96, 1.10) |
| †{Chang, 2015, 3014704 @@author-year} Atlanta, GA, U.S. 1999 – 2005 Time-to-event | N = 3,014,704 | Monitor Means: 17.1 – 17.4 | Reported as figures |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---------------------------------|---|---|
| †{Darrow, 2009, 195818@@author-year} Atlanta, GA, U.S. 1994 – 2004 Time-series | N = 1994 days, 476,789 births | Monitors, daily population weighted spatial averages from 11 monitors Means: 16.4 – 16.5 | Preterm birth (RR) M1: 1.00 (0.98, 1.03) 6 week lag: 0.99 (0.95, 1.02) Within 4 miles of monitor M1: 0.99 (0.93, 1.05) 6 week lag: 1.05 (0.96, 1.16) |
| †{Fleisher, 2014, 2444298@@author-year} Africa, Latin America, Asia 2001 - 2006 Survey | N = 22 counties, >290,000 women | Satellite derived estimates Means: 1.4 – 98.1 | Preterm birth 2001-2006 avg: 0.96 (0.90, 1.02) |
| †{Gehring, 2011, 677057@@author-year} The Netherlands 1996 – 1997 Cohort | N = 677,057 | Land use regression Means: 19.1 – 21.3 | Preterm birth EP: 1.24 (0.82, 1.89) T1: 0.99 (0.83, 1.18) last month: 1.06 (0.85, 1.33) |
| †{Gehring, 2014, 2342497@@author-year} Vancouver, Canada 1999 – 2002 Cohort | N = 68,238 | Land use regression Mean: 4.1 | Moderately preterm birth (30-36 weeks) EP: 1.00 (0.90, 1.16) Very preterm birth (<30 weeks) EP: 1.40 (1.00, 2.01) |
| †{Ha, 2014, 2535539@@author-year} Florida, U.S. 2004 – 2005 Cohort | N = 423,719 | EPA's Hierarchical Bayesian Prediction Model Means: 9.7 – 10.2 | Preterm birth T1: 1.06 (1.03, 1.08) T2: 1.25 (1.22, 1.28) T3: 1.05 (1.02, 1.07) EP: 1.14 (1.10, 1.18) Very preterm birth (<32 weeks) T1: 1.12 (1.05, 1.20) T2: 1.45 (1.37, 1.54) T3: 1.02 (0.95, 1.09) EP: 1.22 (1.12, 1.32) |
| †{Hannam, 2014, 2349678@@author-year} Northwest England 2004 – 2008 Cohort | N = 38,608 | Spatio-temporal model Mean: 22.1 | Preterm birth EP: 0.98 (0.85, 1.12) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|------------------|--|--|
| †{Hyder, 2014, 2337044@@author-year} Connecticut and Massachusetts, U.S. 2000 – 2006 Cohort | N = 834,332 | Monitor Mean: 11.9 Satellite model 1 Mean: 11.4 Satellite model 2 Mean: 11.2 Exposure over entire pregnancy | Preterm birth Monitor: 1.00 (0.98, 1.04) Satellite 1: 0.96 (0.86, 1.04) Satellite 2: 1.00 (0.92, 1.08) |
| †{Kloog, 2012, 1254456@@author-year} Massachusetts, U.S. 2000 – 2008 Cohort | N = 634, 244 | Satellite based model, 10x10 km Mean: 9.6 | Preterm birth EP: 1.03 (0.54, 0.63) |
| †{Lee, 2013, 1258306@@author-year} Pittsburgh, PA, U.S. 1997 - 2002 Cohort | N = 34,703 | Space-time ordinary kriging from monitors, to zip code Mean: 15.6 | Preterm birth T1: 1.13 (1.01, 1.26) Non-smokers T1: 1.14 (0.99, 1.30) Smokers T1: 1.05 (0.85, 1.31) |
| †{Padula, 2014, 2533398@@author-year} San Joaquin Valley, CA, U.S. 2000 – 2006 Cohort | N = 263,204 | monitors, inverse distance squared weighing, within 50km Mean: NR 4 th quartile compare to 1 st quartile PM exposure | PTB, 34-36 weeks, EP: 1.27 (1.23, 1.31) PTB, 32-33, EP: 1.56 (1.44, 1.68) PTB, 28-31, EP: 1.62 (1.45, 1.78) PTB, 24-27, EP: 1.96 (1.68, 2.30) PTB, 20-23, EP: 1.08 (0.85, 1.38) PTB, 34-36 weeks, T1: 1.03 (1.00, 1.06) PTB, 32-33, T1: 0.96 (0.89, 1.03) PTB, 28-31, T1: 0.94 (0.86, 1.04) PTB, 24-27, T1: 0.78 (0.66, 0.91) PTB, 20-23, T1: 0.64 (0.51, 0.81) PTB, 34-36 weeks, T2: 1.09 (1.05, 1.12) PTB, 32-33, T2: 1.21 (1.12, 1.30) PTB, 28-31, T2: 1.55 (1.41, 1.70) PTB, 24-27, T2: 2.14 (1.84, 2.50) PTB, 20-23, T2: 2.83 (2.29, 3.50) PTB, 34-36 weeks, T3: 0.96 (0.93, 1.00) PTB, 32-33, T3: 1.03 (0.96, 1.12) PTB, 28-31, T3: 1.34 (1.22, 1.48) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|------------------|--|---|
| †{Pereira, 2013, 2332545@@author-year} Connecticut, U.S. 2000 – 2006 Longitudinal cohort | N =29,175 women | Monitor, nearest within 40km Means: 12.13 – 12.41 | Preterm birth T1: 1.15 (1.04, 1.25) T2: 0.90 (0.82, 0.99) T3: 1.08 (1.00, 1.14) EP: 1.30 (1.00, 1.29) White women T1: 1.03 (0.92, 1.16) T2: 0.91 (0.80, 1.04) T3: 1.05 (0.96, 1.14) EP: 1.04 (0.76, 1.48) Black women T1: 1.25 (0.97, 1.59) T2: 0.90 (0.69, 1.15) T3: 1.15 (0.97, 1.35) EP: 2.03 (0.98, 4.24) Hispanic women T1: 1.38 (1.12, 1.69) T2: 0.79 (0.64, 0.97) T3: 1.17 (1.01, 1.35) EP: 1.79 (1.00, 3.24) |
| †{Pereira, 2014, 2535984@@author-year} Perth, Australia 1997 – 2007 Longitudinal cohort | N = 39,189 women | Monitor, nearest within 40km Means: 8.51 – 8.56 | Preterm birth EP: 0.95 (0.77, 1.22) T1: 1.00 (0.82, 1.22) T2: 1.00 (0.82, 1.22) T3: 0.90 (0.73, 1.10) Premature rupture of membranes EP: 1.10 (0.95, 1.28) T1: 1.00 (0.86, 1.16) T2: 1.16 (1.00, 1.34) T3: 1.10 (1.00, 1.28) |
| †{Pereira, 2015, 3008953@@author-year} Rochester, NY, U.S. 2004 – 2012 Longitudinal cohort | N = 3,264 women | Monitor, nearest within 40km Mean: 9 | Preterm birth EP: 2.19 (1.40, 3.44) T1: 1.69 (1.22, 2.29) T2: 1.54 (1.10, 2.10) T3: 1.34 (1.00, 1.84) Premature rupture of membranes EP: 1.00 (0.86, 1.22) T1: 0.95 (0.82, 1.10) T2: 0.95 (0.82, 1.16) T3: 0.95 (0.73, 1.22) |
| †{Rudra, 2011, 732732@@author-year} Washington, U.S. 1996 – 2006 Cohort | N = 3,509 women | Land use regression Mean: 10.8 | Preterm birth Last 3 months: 0.74 (0.39, 1.48) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|-------------------------------------|---|--|
| †{Salihu, 2012, 2572094@@author-year} Hillsborough County, Florida, U.S. 2000 – 2007 Cohort | N = 103,961 | Monitor Mean: 11.28 | Preterm birth Exposed v. unexposed, EP: 1.03 (0.98, 1.07) Very preterm birth (<33 weeks) Exposed v. unexposed, EP: 1.05 (0.93, 1.18) |
| †{Stieb, 2015, 3010154@@author-year} Canada 1999 – 2008 Cohort | N = 2,781,940 | Land use regression based on monitor and satellite data to postal code Mean: 8.33 – 8.51 | Preterm birth EP: 0.95 (0.92, 0.98) |
| †{Trasande, 2013, 1521270@@author-year} United States 2000, 2003, 2006 Cross-sectional | N = 222,359 | Monitors averaged within 10 miles Mean: 12.63 | Preterm birth Month of birth: 0.86 (0.82, 0.90) |
| {Warren, 2012, 1668664@@author-year} Texas, U.S. 2002 – 2004 Cohort | N = 32,170 | Monitors, CMAQ model Mean: NR | Reported as figures |
| †{Wilhelm, 2011, 831593@@author-year} Los Angeles County, CA, U.S. 6/1/04 - 3/31/06 Case-control | N = 10,265 cases, 102,2650 controls | Southern California Air Quality Management District Multiple Air Toxics Exposure Study Monitors Mean: 18 | Preterm birth EP: 1.28 (1.05, 1.54) |
| †{Wu, 2009, 190995@@author-year} LA and Orange Counties, CA, U.S. 1997 – 2006 Cohort | N = 1997 - 2006 | CALINE4 line-source dispersion model Mean: 1.82 | Preterm birth (<37 weeks) EP: 1.03 (1.01, 1.06) Moderate preterm birth (<35 weeks) EP: 1.07 (1.03, 1.12) Very preterm birth (<30 weeks) EP: 1.18 (1.10, 1.26) |
| †{Wu, 2011, 758517@@author-year} LA and Orange Counties, CA, U.S. 1997 – 2006 Cohort | N = 1997 - 2006 | CALINE4 line-source dispersion model Mean: 1.8 Monitor Mean: 17.3 | Preterm birth Monitor, LA, EP: 1.22 (0.73, 2.01) Monitor, Orange, EP: 1.54 (1.00, 2.49) CALINE4, LA, EP: 1.22 (1.00, 1.47) CALINE4, Orange, EP: 1.10 (0.86, 1.40) Very preterm birth (<30 weeks) Monitor, LA, EP: 1.16 (0.35, 3.71) Monitor, Orange, EP: 4.16 (0.95, 17.37) CALINE4, LA, EP: 2.19 (1.34, 3.57) CALINE4, Orange, EP: 2.10 (1.05, 4.32) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|------------------|---|---|
| †{Lavinge, 2016, 3223161@@author-year} Ontario, Canada 2005 - 2012 Cohort | N = 818,400 | Satellite based model, 1x1 km Mean: 9.2 | Preterm birth EP: 1.10 (1.06, 1.15) |
| †{Defranco, 2016, 3260576@@author-year} Ohio, U.S. 2007 – 2010 Cohort | N = 224,921 | Monitor Mean: 12.93 – 13.19 | Preterm birth >15µg v. <15µg EP: 1.19 (1.09, 1.30) T1: 1.02 (0.97, 1.07) T2: 0.96 (0.90, 1.01) T3: 1.28 (1.20, 1.37) |
| †{Hao, 2016, 3285878@@author-year} Georgia, U.S. Jan 1 2002 - Feb 28 2006 Cohort | N = 511,658 | Model, fused CMAQ Mean: 11.44 | Preterm birth EP: 1.05 (1.01, 1.09) T1: 1.00 (0.99, 1.03) T2: 1.03 (1.01, 1.05) T3: 1.01 (0.99, 1.03) |
| †{Johnson, 2016, 3361758@@author-year} New York City, NY, U.S. 2008 – 2010 Cohort | N = 258,294 | Combination of NYC community air survey (spatial) and regulatory monitors (temporal), within 300m Mean: 11 | Preterm birth T1: 0.98 (0.95, 1.02) T2: 0.97 (0.94, 1.01) Spontaneous preterm birth T1: 0.99 (0.95, 1.04) T2: 0.99 (0.95, 1.04) Medically indicated preterm birth T1: 0.97 (0.92, 1.03) T2: 0.97 (0.92, 1.04) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|--|------------------------|--|--|
| †{Mendola, 2016, 3224121@@author-year} United States 2002 – 2008 Cohort | N = 223,502 deliveries | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Exposures lagged before hour of admission for delivery Means: 11.78 – 11.92 | Preterm birth, no asthma 3 months preconception: 0.91 (0.86, 0.95) weeks 1-7: 1.04 (1.02, 1.06) weeks 8-14: 0.97 (0.95, 0.99) weeks 15-21: 0.97 (0.95, 0.99) weeks 22-28: 0.99 (0.97, 1.01) last 6 weeks: 0.92 (0.90, 0.94) EP: 1.01 (0.99, 1.03) Preterm birth, asthma 3 months preconception: 0.96 (0.83, 1.10) weeks 1-7: 1.07 (1.01, 1.13) weeks 8-14: 1.02 (0.96, 1.07) weeks 15-21: 0.98 (0.93, 1.04) weeks 22-28: 1.00 (0.94, 1.06) last 6 weeks: 0.99 (0.94, 1.05) EP: 1.05 (0.99, 1.12) Very preterm birth (<34 weeks), no asthma 3 months preconception: 0.79 (0.72, 0.86) weeks 1-7: 1.04 (0.99, 1.07) weeks 8-14: 0.97 (0.94, 1.01) weeks 15-21: 1.01 (0.97, 1.04) weeks 22-28: 0.93 (0.89, 0.96) last 6 weeks: 0.89 (0.87, 0.92) EP: 1.02 (0.98, 1.05) Very preterm birth (<34 weeks), asthma 3 months preconception: 0.79 (0.64, 0.96) weeks 1-7: 1.10 (0.99, 1.21) weeks 8-14: 1.02 (0.93, 1.12) weeks 15-21: 1.05 (0.95, 1.14) weeks 22-28: 0.99 (0.91, 1.09) last 6 weeks: 1.03 (0.94, 1.13) EP: 1.12 (1.01, 1.24) |
| †{Laurent, 2016, 3361478@@author-year} Los Angeles County, CA, U.S. 2001 – 2008 Nested case-control | N = 442,314 | Empirical Bayesian kriging from monitors Mean: NR Exposures are length of case pregnancy | Preterm birth 1.10 (1.09, 1.11) Adjusted for O3 1.09 (1.08, 1.10) Adjusted for NO2 1.11 (1.09, 1.12) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|-----------------------------------|--|---|
| †{Qian, 2015, 3072421@@author-year} Wuhan, China 2011 – 2013 Cohort | N = 95,911 | Monitor Means: 70.8 (14.4) | Preterm birth EP: 1.03 (1.02, 1.05) T2: 1.02 (1.02, 1.03) Adjusted for SO ₂ EP: 1.04 (1.02, 1.05) Adjusted for NO ₂ EP: 1.03 (1.02, 1.05) Adjusted for CO EP: 1.03 (1.01, 1.04) Adjusted for O ₃ EP: 1.03 (1.02, 1.04) |
| †{Lavinge, 2016, 3223161@@author-year} Ontario, Canada Jan 1 2005 - March 31 2012 Cohort | N = 818,400 singleton live births | Satellite based estimates, 1x1 km Means: 9.07 – 9.20 | Reported as figure |
| †{Wallace, 2016, 3223972@@author-year} United States 2002 – 2008 Cohort | N = 223,375 | Model, specialized CMAQ, bias corrected with monitor data Averaged over delivery hospital referral region Exposures lagged before hour of admission for delivery Means: 11.78 – 11.92 | Premature rupture of membranes Adjusted for all pollutants EP: 0.93 (0.94, 1.02) Preterm premature rupture of membranes Adjusted for all pollutants EP: 0.87 (0.72, 1.03) |
| †{Dadvand, 2013, 2233524@@author-year} Barcelona, Spain 2002 - 2005 Cohort | N = 5,555 singleton live births | Land use regression Mean: NR | Premature rupture of membranes EP: 1.08 (0.67, 1.74) last 3 months: 1.13 (0.76, 1.70) |

CMAQ community multiscale air quality modeling system, C-RP: C-reactive protein, EP: entire pregnancy, FR: fecundity ratio M1: 1st month of pregnancy, IRR: incidence rate ratio, M7: 7th month of pregnancy, OR: odds ratio, RR: risk or rate ratio, T1: 1st trimester of pregnancy, T2: 2nd trimester of pregnancy, T3: 3rd trimester of pregnancy.

^aAll estimates reported per 5µg increase in PM_{2.5} unless otherwise stated

†Studies published since the 2009 Integrated Science Assessment for Particulate Matter.

Table S9-4: Summary of epidemiologic studies of exposure to PM2.5 and birth defects

| Study | Outcomes Examined | Location (sample size) | Mean PM _{2.5} (µg/m ³) | Exposure Assessment | Exposure Window |
|---|--------------------|---|---|--|----------------------------------|
| Short-term exposure | | | | | |
| {Stingone, 2014, 2324782@@author-year} | Cardiac defects | Arkansas, Iowa, Massachusetts, California, Georgia, New York, North Carolina, Texas, and Utah, U.S. (n= 79 - 1718 cases depending on defect) | Median: 11.6 | Nearest monitor within 50 km | Weeks 2-8 of gestation |
| {Zhu, 2015, 3002759@@author-year} | Oral cleft defects | United States (n = 188,102) | Median: 10.37 – 11.74 | Bias corrected modeled concentrations (specialized CMAQ) for delivery hospital referral region | Weeks 1-10 of gestation |
| {Warren, 2016, 3361809@@author-year} | Cardiac defects | Arkansas, Iowa, Massachusetts, California, Georgia, New York, North Carolina, Texas, and Utah, U.S. (n= 79 - 1718 cases depending on defect) | NR | CMAQ, downscaled model | Daily for weeks 2-8 of gestation |
| Long-term exposure | | | | | |
| {Agay-Shay, 2013, 1640394@@author-year} | Cardiac defects | Israel 135,527 births, 5,125 cases | 26.1 | Inverse distance weighing, 2 – 5 monitors | Weeks 3-8 of gestation |
| {Marshall, 2010, 597374@@author-year} | Oral cleft defects | New Jersey, U.S. 717 cases | 13.4 | Nearest monitor, within 40km | Weeks 3-8 of gestation |
| {Padula, 2013, 1641723@@author-year} | Cardiac defects | California, U.S. 813 cases, 828 controls | Median: 14.82 | Inverse distance weighing, 1 – 4 monitors | Months 1 and 2 of gestation |

| Study | Outcomes Examined | Location (sample size) | Mean PM_{2.5} (µg/m³) | Exposure Assessment | Exposure Window |
|---|--|---|---|---|--|
| {Padula, 2013, 1518997@@author-year} | Neural tube defects, oral cleft defects, gastroschisis | California, U.S. 806 cases, 849 controls | Median: 14.82 | Inverse distance weighing, 1 – 4 monitors | Months 1 and 2 of gestation |
| {Padula, 2013, 2331745@@author-year} | Other defects | California, U.S. 874 cases, 849 controls | Median: 14.82 | Inverse distance weighing, 1 – 4 monitors | Months 1 and 2 of gestation |
| {Schembari, 2014, 2231219@@author-year} | Non-chromosomal anomalies | Barcelona, Spain 2247 cases, 2991 controls | median: 16.6 | Land use regression with temporal adjustment | Weeks 3-8 of gestation |
| {Vinikoor-Imler, 2015, 3012808@@author-year} | Various | Texas, U.S.; 21,060 cases, 1,401,611 controls all Texas; 291 cases 521 controls NBDPS | 8.2 | CMAQ model | 1 st trimester |
| {Vinikoor-Imler, 2013, 2220006@@author-year} | Various | North Carolina, U.S. 322,969 births | 14.03 | CMAQ model | Weeks 3-8 of gestation |
| {Jurewicz, 2014, 2348881@@author-year} | Chromosomal disomies | Poland 212 infertile men | 35.64 | Nearest monitor | 90 days before sampling |
| {Tanner, 2015, 3023391@@author-year} | Various | Florida, U.S. 156-1653 cases depending on defect | NR | Inverse distance squared weighing, monitors within 50km and 3 days | Weeks 3-12 of gestation depending on defect |
| {Girgus, 2016, 3108700@@author-year} | Cardiac, neural tube, and orofacial defects | Massachusetts, U.S. 2729 cardiac cases, 255 neural tube cases, 729 orofacial cases; 7816 controls | NR | Modeled from satellite, meteorological, and land use data | Weeks 3-7 of gestation |

| Study | Outcomes Examined | Location (sample size) | Mean PM_{2.5} (µg/m³) | Exposure Assessment | Exposure Window |
|--|--------------------------|---|---|--|---|
| {Zhu, 2015, 3002759@@author-year} | Orofacial defects | United States 63 cleft palate cases, 159 cleft lip w/wo palate cases | Median: 10.37 - 11.74 | Bias corrected modeled concentrations (specialized CMAQ) for delivery hospital referral region | 3 months preconception, weeks 3-7 of gestation |
| {Zhang, 2016, 3361587@@author-year} | Cardiac defects | Wuhan, China 105,988 births | 65.61 | Nearest monitor | Months 1 to 3 of gestation |

CMAQ =community multi-scale air quality modeling system; km = kilometer; NR = not reported

Table S9-5. Studies of fetal and infant mortality

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|--|--|--|
| Short term studies | | | |
| †{Faiz, 2013, 1640388@@author-year} New Jersey, U.S. 1999 – 2004 Case-crossover | N = 689 infants | Monitor, within 10km Mean: 15 | Lag 2: 1.03 (0.96, 1.10) Lag 2, adjusted for O3: 0.98 (0.90, 1.08) Lag 2, adjusted for SO2: 1.00 (0.93, 1.09) Lag 2, adjusted for CO: 1.04 (0.95, 1.14) |
| †{Yorifuji, 2016, 3120028@@author-year} Tokyo, Japan 2002 – 2013 Case-crossover | N = 2086 infants | Monitor Median: 16.7 | Lag 0 All infant mortality: 1.03 (1.00, 1.06) Neonatal: 1.01 (0.97, 1.05) Post-neonatal: 1.05 (1.01, 1.09) Cardiac: 0.96 (0.82, 1.12) Respiratory: 1.14 (1.00, 1.29) Perinatal circumstances: 1.00 (0.95, 1.06) Birth defects: 1.04 (0.99, 1.09) SIDS: 1.05 (0.94, 1.17) |
| †{Arroyo, 2015, 3425187@@author-year} Madrid, Spain 2004-2009 Time-series | N = 314 weeks | Monitor Mean: 17.1 | Late fetal death (within 1 st 24 hrs of life) Week 31 (lag 6 weeks): 1.06 (1.05, 1.06) ^b |
| Long term studies | | | |
| †{Enkhmaa, 2014, 2348703@@author-year} Ulaanbaatar, Mongolia 2009-2011 | N = 1219 | Monitor | Strong correlation coefficients between monthly PM2.5 and monthly counts of spontaneous abortion before 20 weeks of gestation (>0.8) |
| †{DeFrance, 2015, 3012715@@author-year} Ohio, U.S. 2006-2010 Cohort | N = 351,036 births | Monitor, within 10km Mean: 13.3 | Stillbirth, >20 weeks T1, >17.2 v. <17.2 0.77 (0.58, 1.02) T2, >16.26 v. <16.26 0.80 (0.62, 1.04) T3, >16.22 v. <16.22 1.42 (1.06, 1.91) EP, >15.67 v. <15.67 1.21 (0.96, 1.53) |
| †{Faiz, 2012, 1254455@@author-year} New Jersey, U.S. 1998-2004 Cohort | N = 756,562 births (5381 stillbirths) | Monitor, within 10km Means: 13.7-14.3 | Stillbirth, >20 weeks EP: 1.09 (0.83, 1.43) T1: 1.19 (0.95, 1.48) T2: 1.18 (0.95, 1.46) T3: 1.10 (0.74, 1.63) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---------------------------------|--|---|
| †{Green, 2015, 2826673@@author-year} California, U.S. 1999-2009 Cohort | N = 13,999 | Monitor, nearest to population weighted zipcode centroid within 20km Means: 15.20 - 15.45 | Stillbirth, >20 weeks T1: 1.00 (0.98, 1.02) T2: 1.01 (0.99, 1.03) T3: 1.00 (0.98, 1.03) EP: 1.03 (0.99, 1.06) Adjusted for NO2 T1: 0.98 (0.95, 1.02) T2: 1.00 (0.96, 1.03) T3: 1.00 (0.96, 1.05) EP: 0.98 (0.93, 1.05) Adjusted for O3 T1: 1.00 (0.98, 1.02) T2: 1.00 (0.98, 1.02) T3: 1.00 (0.98, 1.03) EP: 1.02 (0.99, 1.06) By air basin: Sacramento valley: 1.16 (1.00, 1.35) San Diego county: 1.09 (0.90, 1.32) San Francisco Bay: 1.15 (0.97, 1.36) San Joaquin Valley: 1.07 (1.00, 1.15) South Central Coast: 1.09 (0.79, 1.51) South Coast: 1.04 (0.99, 1.09) |
| †{Son, 2011, 785950@@author-year} Seoul, South Korea 2004-2007 Survival cohort | N = 359,459 births (225 deaths) | Monitor Means: 30.4-30.6 | All cause post-neonatal infant mortality Normal birth weight EP + life: 1.96 (1.37, 2.77) T1: 1.25 (1.06, 1.48) T2: 1.25 (0.94, 1.67) T3: 1.10 (0.83, 1.46) Low birth weight EP + life: 1.00 (0.18, 5.54) T1: 1.05 (0.48, 2.30) T2: 1.46 (0.47, 4.50) T3: 0.77 (0.30, 1.98) Respiratory (n=26) EP + life: 6.18 (1.44, 26.33) T1: 2.07 (1.23, 3.47) T2: 1.15 (0.46, 2.84) T3: 1.82 (0.69, 4.78) SIDS (n=22) EP + life: 1.74 (0.58, 5.33) T1: 1.23 (0.73, 2.09) T2: 0.83 (0.38, 1.84) T3: 0.70 (0.31, 1.61) |

| Study | Study Population | Exposure Assessment | Effect Estimates (95% CI) ^a |
|---|---|---|---|
| {Woodruff, 2008, 98386@author-year} United States 1999-2002 Cohort | N = ~3.5 million births (6,639 deaths) | Monitors, county average Means: 14.5 – 14.9 Exposures over 1 st 2 months of life | Post-neonatal infant mortality All-cause: 1.03 (0.99, 1.08) Respiratory 1.08 (0.97, 1.20) Adjusted for CO: 1.04 (0.92, 1.17) SIDS 1.01 (0.90, 1.14) Adjusted for CO 1.03 (0.91, 1.16) Ill-defined + SIDS 1.04 (0.98, 1.12) Other 1.02 (0.97, 1.08) |

CMAQ community multiscale air quality modeling system, C-RP: C-reactive protein, EP: entire pregnancy, FR: fecundity ratio M1: 1st month of pregnancy, IRR: incidence rate ratio, M7: 7th month of pregnancy, OR: odds ratio, RR: risk or rate ratio, T1: 1st trimester of pregnancy, T2: 2nd trimester of pregnancy, T3: 3rd trimester of pregnancy.

^aAll estimates reported per 5µg increase in PM_{2.5} unless otherwise stated

[†]Studies published since the 2009 Integrated Science Assessment for Particulate Matter.