

Pollution and Infant Health

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ABSTRACT—*In this article, I review recent research showing that even relatively low levels of pollution can affect infants' health. This research attempts to go beyond documenting correlations by using sharp changes in pollution levels, carefully selecting control groups (including unexposed siblings as controls for exposed children), and considering behavioral responses to pollution such as maternal mobility. Poor and minority children are more likely to be affected, and differential exposure could be responsible for some of the observed group-level differences in health at birth. Policy makers concerned about the roots of inequality should consider the role played by environmental exposures of pregnant mothers.*

KEYWORDS—*air pollution; toxics; Superfund; low birth-weight; environmental justice; infant health*

High levels of pollution can lead to illness and death. For example, the London Fog of 1952, which trapped pollutants from coal fires and other sources over London for 4 days, resulted in as many as 12,000 deaths (Bell & Davis, 2001). However, it is not clear whether the lower levels of ambient pollution in wealthy countries today affect health. For example, the Environmental Protection Agency (EPA) regards levels of carbon monoxide (CO) of 30–50 parts per million (ppm) as hazardous, but these levels seldom occur now in the developed world (U.S. EPA, 2006); “moderate” levels of pollution of 4–9 ppm are encoun-

tered more frequently (e.g., Currie, Neidell, & Schneider, 2009).

In this review, I focus on whether these low levels of pollution significantly affect infants' health. Although most people in rich countries are no longer subjected to levels of pollution like the London Fog, more people than ever may be subjected to low levels of pollution given increased urbanization, traffic congestion, and the long list of chemicals in everyday use. Some argue that increasing rates of disabilities such as asthma, autism, and attention deficit hyperactivity disorder (ADHD) in many rich countries might be due to pervasive low-level environmental exposure (Rauch & Lanphear, 2012).

The developing fetus and very young children may be particularly vulnerable to environmental pollution because they are more likely to be affected during a critical developmental period. Some important defenses against toxic chemicals, such as the blood–brain barrier, are not yet in place in young children. And a given “dose” of pollution is proportionately larger for young children. Studying infants is practical for several reasons: Information is collected about every infant born in the United States and other wealthy countries, via the vital registration systems, and the time between potential exposure and health outcomes is shorter for infants than adults for whom exposures many years ago may affect current health. Infants are also of special interest given that health at birth predicts later adult outcomes such as education and earnings (see Almond & Currie, 2010, for a review).

METHODOLOGICAL AND MEASUREMENT ISSUES

Pollution is associated with negative health outcomes in infants (DeRegnier & Desai, 2010; Engle, 2010; Evans, 2006; Walker et al., 2011). However, other characteristics of children, such as living in poverty, are correlated with exposure to pollution, and these factors independently predict bad outcomes. If poverty, rather than pollution, causes poor outcomes, for example, then the policy implications are quite different.

In this review, I focus on studies that attempt to get at the causal effect of pollution, using sharp variations in pollution levels, carefully drawn comparison groups, and strategies such

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as sibling comparisons to control for differences in family background. These studies also consider maternal mobility and other behavioral responses, which often make it difficult to establish a causal connection between pollution and health. For example, if healthier women tend to move away from a pollution source, then the mean health of those around the source will deteriorate over time, but this deterioration does not reflect a physical effect of pollution. Suppose, for example, 10 people live in the area of a pollution source—5 are sick and 5 are healthy. The mean rate of illness is 50%. However, if the 5 healthy people leave the area after the source starts polluting and the 5 sick people stay, the mean rate of illness in the area increases to 100% even absent a change in the actual number of sick people. Failing to control for mobility as a potential confounder could lead to estimates of the effects of pollution that are either too high (as in this example) or too low. The studies discussed here do not measure individual exposure to pollution, but focus on potential exposure to pollution that occurs because of ambient pollution levels near people's residences. If individuals protect themselves against harmful ambient pollution, these studies underestimate the effects of an individual's exposure to a given level of pollution. Thus, if these studies demonstrate that low or moderate pollution levels are associated with harmful health consequences, the estimates can be viewed as providing a lower bound on true health effects.

Much of the literature focuses on a few air pollutants. Since the passage of the Clean Air Acts of 1970, six criterion air pollutants—particulate matter, CO, ozone, lead, sulfur dioxide, and nitrous oxides—have been routinely monitored in the United States and other countries. Less is known about other hazardous pollutants. Industrial plants in the United States emit approximately 4 billion pounds of toxic pollutants annually, including more than 80,000 different chemical compounds (U.S. Government Accountability Office, 2009). Regulation of these toxics is in its infancy and most pollutants have not undergone any form of toxicity testing (U.S. Centers for Disease Control and Prevention, 2009). For example, the Mercury and Airborne Toxics Standards, unveiled in December 2011, represent the first regulation of mercury compounds in the United States, although we have known for decades that mercury is highly toxic.

EFFECTS OF AIR POLLUTION ON HEALTH AT BIRTH

Two landmark studies of air pollution were among the first to try to measure the causal effect of air pollution on infant health (Chay & Greenstone, 2003a, 2003b). In the first (Chay & Greenstone, 2003a), counties that were out of compliance with new pollution thresholds of the U.S. Clean Air Acts were required to lower pollution, while counties with pollution levels just below the thresholds were not required to implement any changes. Hence, counties initially just below the threshold form a natural control group for those just above the threshold. Using these comparisons, a one-unit decline in par-

ticulates was shown to lead to 5 to 8 fewer infant deaths per 100,000 live births.

The second study (Chay & Greenstone, 2003b) looked at the recession of 1982, which lowered pollution in areas where plants closed. When pollution declined, infant mortality also declined. Similarly, in an investigation of the impact on health of the closure and reopening of a steel mill in Utah in the 1980s, preterm births declined when the mill was closed but rebounded when it reopened (Parker, Mendola, & Woodruff, 2008).

These studies were influential in popularizing a natural experiment approach to studying the effects of pollution on health. However, the levels of particulates examined in these studies are much greater than those prevalent today; for example, U.S. PM10 (particulate matter of 10 μm or less) levels fell nearly 50% from 1980 to 2000. Moreover, only the effects of particulates were not measured in the 1970s and early 1980s.

Other studies used naturally occurring variation in pollution and large samples of U.S. siblings subjected to different levels of pollution in utero (Currie & Neidell, 2005; Currie et al., 2009). This design controlled for fixed elements of family background shared by siblings. For example, the second study began with 1.5 million birth records for the period 1989–2006, focusing on mothers who lived near pollution monitors. Babies exposed in utero to higher levels of CO (which comes largely from vehicle exhaust) had a younger gestational age at birth and weighed less than their siblings, even though ambient CO levels were generally lower than current EPA standards. In both studies, moving from an area with higher levels of CO to one with lower levels had a larger effect on infant health than convincing a pregnant woman smoking 10 cigarettes a day to quit. Moreover, CO exposure increased the risk of death among newborns by 2.5%. The negative effects of CO were 5 times greater for smokers than for non-smokers, suggesting that the same levels of pollution might be more harmful for infants already at risk of poor birth outcomes.

Studies relying on natural experiments have recently been conducted in other countries. In Germany, CO harmed infants' health (Coneus & Spiess, 2010). In Turkey, following the switch from coal to natural gas, a 1 percentage point increase in subscriptions to natural gas was associated with a 4% decline in infant mortality (Cesur, Tekin, & Ulker, 2013). In Mexico City, in a study on the effect of thermal inversions, which trapped pollution over the city, increases in CO affected infant mortality more than in the United States (Arceo-Gomez, Hanna, & Oliva, 2012); apparently, the same increase may have a stronger effect when starting from a higher base level.

Carbon monoxide comes mostly from cars; New Jersey and Pennsylvania introduced an electronic toll-collection device called E-ZPass in a staggered fashion between 1997 and 2001. As much of the pollution produced by cars occurs when the car is idling or accelerating to highway speed, E-ZPass reduces auto emissions near toll plazas. In a study on the effect of car exhaust on infants' health, mothers who lived near toll plazas were compared with mothers who lived along the same busy roadways but

slightly farther away (Currie & Walker, 2011); E-ZPass reduced CO by about 40% in the vicinity of the toll plazas and also reduced many other pollutants found in vehicle exhaust. Both low birthweight (birthweight < 2,500 g) and prematurity (gestation < 38 weeks) fell by about 10% in the 2 km surrounding a toll plaza compared to the area 2–10 km from the toll plaza but still within 3 km of a busy road. Similar results were found in a sample of mothers who lived near toll plazas comparing siblings born before and after adoption of E-ZPass.

Similar results also emerged in a study of the effect of traffic congestion in California. Traffic jams that temporarily increased pollution levels, even from a relatively low base level of pollution, significantly affected rates of infant mortality (Knittel, Miller, & Sanders, 2011).

Little research has examined the health effects of chemicals other than the criterion air pollutants. In a study of U.S. county-level data from the Toxics Release Inventory (TRI tracks emissions of certain toxic chemicals that may pose a threat to human health and the environment), higher emissions were correlated with infant death (Currie & Schmeider, 2009). A subsequent study (Currie, Davis, Greenstone, & Walker, 2013) examined the effects of toxic emissions using openings and closures of more than 1,600 industrial plants reporting toxic emissions. Data on 11 million individual birth records from five large states (Florida, Michigan, New Jersey, Pennsylvania, and Texas) for 1989–2003 were matched with data about pollution levels from monitoring stations. On average, toxics were detected a mile away from a plant (Currie, Davis, et al., 2013; Currie, Graff-Zivin, Meckel, Neidell, & Schlenker, 2013). In fact, the average mother in these states lived within a mile of a plant emitting toxics. Living this close increases the incidence of low birthweight by 2% relative to infants born 1–2 miles away (where economic benefits of plant operation can be assumed to be the same as for people living within a mile of a plant). Housing values are also reduced, but only within a half mile of a plant, suggesting that some people at risk of poor health outcomes are unaware of the hazards.

Few studies in the United States or elsewhere have examined the effect on infant health of exposure to water pollution during pregnancy. One study looked at the effects of chemical violations of drinking water quality standards in New Jersey from 1997 to 2007, comparing infants who may have been exposed to contaminated drinking water in utero with siblings who were not (Currie, Graff-Zivin, et al., 2013). Contamination of drinking water yielded small effects on birthweight and length of gestation among all infants, but large and statistically significant negative effects on these outcomes among infants born to mothers with less education.

LONG-TERM CONSEQUENCES OF POLLUTION EXPOSURE IN EARLY LIFE

Most studies on the health effects of exposure to pollution examine short-term effects; studies that follow children exposed to

pollution early in life into adulthood are rare. However, even in the absence of such data, cohorts of children who were affected by an environmental shock can be examined. By comparing affected children with those born just before or just after a shock, researchers may be able to judge the magnitude of the effect.

One such study looked at the fallout from the Chernobyl nuclear disaster using Swedish data (Almond, Edlund, & Palme, 2009). The cloud of radiation affected some areas but not others and can be mapped precisely. In this comparison of cohorts in affected and unaffected areas, and cohorts in utero just prior to the disaster and during the disaster, radiation exposure reduced mathematics test scores 6% despite the fact that, at the time, the amounts of radiation involved were considered to be so low as to be completely harmless.

Richer data were used to investigate the long-term impact of banning leaded gasoline in Sweden during the 1970s (Nilsson, 2009). A decline in ambient lead (measured from samples of moss) was linked to later outcomes for the affected cohorts. At the time of the ban, peak blood lead levels in Swedish children were already below the current threshold for concern in the United States (10 µg per deciliter), suggesting that the results of this study are relevant to current discussions about a safe level of lead exposure in the United States. In Sweden, reducing levels from 10 to 5 µg per deciliter increased high school graduation rates 2.3% and increased earnings among young adults 5.5%. The same exposures yielded larger effects among children of lower socioeconomic status (SES). In short, the evidence suggests that lead is harmful in the long term at levels below current U.S. thresholds for concern.

Another study also used a cohort comparison approach, building on the work of Chay and Greenstone by asking whether cohorts of infants affected by reductions in U.S. pollution caused by the recession of the early 1980s had higher high school test scores (Sanders, 2010). The study did not have information about where mothers lived when the children were in utero, but assumed that children were born where they attended school. That said, a 1 *SD* decrease in total suspended particles while the child was in utero was associated with an increase of 1.87% of a standard deviation in high school test scores.

HEALTH AT BIRTH AND ENVIRONMENTAL JUSTICE

The environmental justice hypothesis holds that poor and minority households are more likely to be exposed to pollution (see Bowen, 2002, for a critical review). If exposure to environmental pollution is an important determinant of infant health, then inequities in exposure could lead to persistent group-level differences in health at birth. Figure 1 illustrates differences in health at birth using data on all U.S. births in 1989 and 2010 from national Vital Statistics Natality files. The endpoints chosen are the 1st year the revised certificate of live birth became widely used and the most recent year available. In the United

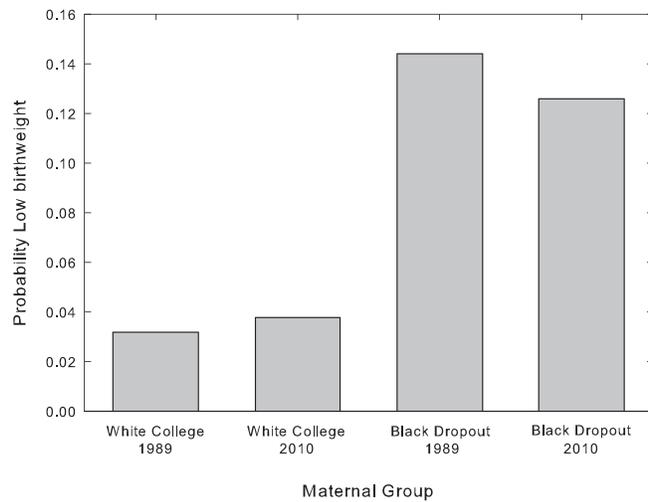


Figure 1. Fraction of low birthweight births in two groups of mothers. (Source: author's calculations from Vital Statistics Natality records)

States, the incidence of low birthweight is 3 times greater among African American mothers who dropped out of high school than among White, college-educated mothers, though the disparity has narrowed slightly over the past 20 years.

Can these differences be partially explained by differences in fetal exposure to pollution? Using the five-state data set introduced earlier, data from birth records were combined with information about two sources of pollution: hazardous waste sites listed in the Superfund program and industrial plants listed in the TRI (Currie, 2011). Distance between the mother's residence, Superfund sites, and industrial plants also was calculated.¹

Figure 2 shows that in these five states, non-Whites are more likely to live within 2,000 m (1.25 miles) of a plant that emits toxics or a Superfund site. Within race, less educated mothers were more likely to live near a plant, although the effect was smaller than the effect of race. These raw differences could reflect other characteristics that are correlated with both race/ethnicity and residential location. However, even within zip codes and after controlling for an extensive list of controls, minority mothers are more likely to be exposed to these sources of pollution. Within zip codes, African American and Hispanic women are 5.3 and 4 percentage points more likely than White women to live within 2,000 m of a site, respectively. And less educated and minority women are more likely to live near highway toll plazas, where they are subjected to high levels of exhaust from motor vehicles (Currie & Walker, 2011).

Thus, infants born to minority and low-SES mothers are more likely to be exposed to harmful contaminants in utero, potentially negatively affecting their lives. Although the reasons why

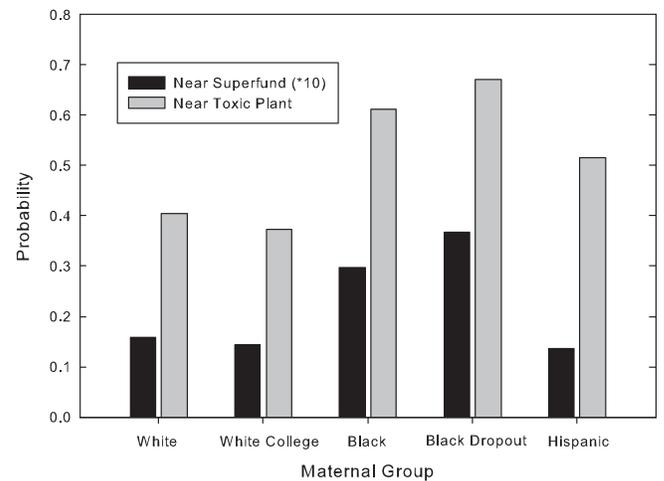


Figure 2. Probability that a mother lives < 2,000 m from a pollution source in five large states. Probabilities of living near a Superfund site are multiplied by 10 in order for the two series to have a comparable scale. (Source: Currie, 2011)

this occurs are disputed, one possible mechanism is through differences in maternal mobility.

WHO MOVES IN RESPONSE TO POLLUTION?

Activists often assert that toxic facilities are purposely situated in poor and minority areas, perhaps because these communities are less able to oppose them. However, people also vote with their feet and respond to changes in the environment. Such mobility can complicate interpretation of the sorts of analyses that I have described. If an area gentrifies in response to an environmental cleanup, then infant health in the area may improve for reasons that have little to do with pollution reduction per se. Census data show that areas in which toxic releases increased (or decreased) experienced losses (or gains) in population between 1990 and 2000, demonstrating that people respond to such changes (Banzhaf & Walsh, 2008).

In an examination of maternal responses to changes in pollution, areas surrounding Superfund sites rapidly became "Whiter" following cleanups (Currie, 2011), and the changes were larger for the most dangerous sites. Similarly, when new information about toxic releases became available, White, college-educated mothers left areas close to toxic plants. Thus, White, college-educated mothers are most likely to benefit from environmental cleanups. However, the composition of mothers around toll plazas was not affected by the institution of E-ZPass, suggesting that mothers are unaware of the negative health effects of traffic congestion (Currie & Walker, 2011).

In summary, one reason minority and low-SES infants are more likely to be exposed to pollutants in utero is that their mothers are less likely to move away from harmful sources of pollution because they are less aware of them, less able to move, or perhaps more concerned about other problems in their lives.

¹Multiple births were excluded because they are more likely to have health problems. However, including multiple births does not alter the conclusions reported here.

DISCUSSION AND CONCLUSIONS

The effect of pollutants on infants' health raises important questions. First, how much of the persistent gap in health at birth is due to exposure to environmental pollution? Answering this question is difficult given the rudimentary state of knowledge regarding the health effects of pollution. One study estimated that 6% of the gap in low birthweight between White, college-educated mothers and African American mothers who dropped out of high school could be due to differences in toxic exposures from industrial plants (Currie, Davis, et al., 2013). However, airborne emissions from toxic plants are not the only source of toxic exposure for the fetus and may not be the most important. For example, widespread exposure to pollution comes from automobile exhaust and households, which use many potential sources of toxicants, including tobacco, plasticizers, and pesticides (see Rauh et al., 2006).

Research is needed on the effects of environmental toxicants and on the immediate effects on fetal health as well as the long-term effects, including possible effects on disabilities that have been linked to low birthweight, such as asthma, autism, and ADHD. Moreover, most research has focused on airborne criterion air pollutants; more research is needed into other air pollutants, water pollution, hazardous waste sites, and sources of pollution in the home. Much of the existing work is limited by its focus on measures like low birthweight, which are crude proxies for health at birth. Ideally, large samples would be available with a broader range of health measures. Finally, we need to consider the fact that the same levels of pollution may have different effects on different groups, and we need to determine how best to remediate outcomes among those who have been harmed.

REFERENCES

- Almond, D., & Currie, J. (2010). Human capital development before age five. In *The handbook of labor economics*, 4b (pp. 1315–1486). Amsterdam, the Netherlands: Elsevier. Retrieved from <http://www.nber.org/papers/w15827>
- Almond, D., Edlund, L., & Palme, M. (2009). Chernobyl's subclinical legacy: Prenatal exposure to radioactive fallout and school outcomes in Sweden. *Quarterly Journal of Economics*, 124, 1729–1772. doi:10.1162/qjec.2009.124.4.1729
- Arceo-Gomez, E. O., Hanna, R., & Oliva, P. (2012). *Does the effect of pollution on infant mortality differ between developing and developed countries? Evidence from Mexico City* (NBER Working Paper No. 18349). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w18349>
- Banzhaf, H. S., & Walsh, R. P. (2008). Do people vote with their feet? An empirical test of Tiebout's mechanism. *American Economic Review*, 98, 843–863. doi:10.1257/aer.98.3.843
- Bell, M. L., & Davis, D. L. (2001). Reassessment of the lethal London Fog of 1952: Novel indicators of acute and chronic consequences of acute exposure to air pollution. *Environmental Health Perspectives*, 109, 389–394. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240556/pdf/ehp109s-000389.pdf>
- Bowen, W. (2002). An analytical review of environmental justice research: What do we really know? *Environmental Management*, 29, 3–15. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/11740620>
- Cesur, R., Tekin, E., & Ulker, A. (2013). *Air pollution and infant mortality: Evidence from the expansion of natural gas infrastructure* (NBER Working Paper No. 18736). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w18736>
- Chay, K. Y., & Greenstone, M. (2003a). *Air quality, infant mortality, and the Clean Air Act of 1970* (NBER Working Paper No. 10053). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w10053>
- Chay, K. Y., & Greenstone, M. (2003b). The impact of air pollution on infant mortality: Evidence from geographic variation in pollution shocks induced by a recession. *Quarterly Journal of Economics*, 118, 1121–1167. doi:10.1162/00335530360698513
- Coneus, K., & Spiess, K. C. (2010). *Pollution exposure and infant health: Evidence from Germany* (German Socio-Economic Panel Working Paper No. 312). Berlin, Germany: DIW Berlin. Retrieved from http://www.diw.de/documents/publikationen/73/diw_01.c.361690.de/diw_sp0312.pdf
- Currie, J. (2011). Inequality at birth: Some causes and consequences. *American Economic Review*, 101, 1–22. doi:10.1257/aer.101.3.1
- Currie, J., Davis, L., Greenstone, M., & Walker, R. (2013). *Do housing prices reflect environmental health risks? Evidence from more than 1600 toxic plant openings and closings* (NBER Working Paper 18700). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w18700.pdf>
- Currie, J., Graff-Zivin, J., Meckel, K., Neidell, M., & Schlenker, W. (2013). *Something in the water: Contaminated drinking water and infant health* (NBER Working Paper No. w18876). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w18876>
- Currie, J., & Neidell, M. (2005). Air pollution and infant health: What can we learn from California's recent experience? *Quarterly Journal of Economics*, 125, 1003–1030. doi:10.1016/j.jhealeco.2009.02.001
- Currie, J., Neidell, M., & Schneider, J. F. (2009). Air pollution and infant health: Lessons from New Jersey. *Journal of Health Economics*, 28, 688–703. doi:10.1016/j.jhealeco.2009.02.001
- Currie, J., & Schneider, J. (2008). *Fetal exposures to toxic releases and infant health* (NBER Working Paper No. 14352). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w14352>
- Currie, J., & Schneider, J. (2009). Fetal exposure to toxic releases and infant health. *American Economic Association Papers and Proceedings*, 99, 177–183.
- Currie, J., & Walker, R. (2011). Traffic congestion and infant health: Evidence from EZPass. *American Economic Journals: Applied Economics*, 3, 65–90. doi:10.1257/app.3.1.65
- DeRegnier, R.-A., & Desai, S. (2010). Bioecological risks—Fetal development. In J. G. Bremner & T. D. Wachs (Eds.), *Wiley-Blackwell handbook of infant development* (Vol. 2, 2nd ed., pp. 9–32). Malden, MA: Blackwell. doi:10.1002/9781444327588
- Engle, P. (2010). Infant development in the developing world. In J. G. Bremner & T. D. Wachs (Eds.), *Wiley-Blackwell handbook of infant development* (Vol. 2, 2nd ed). Malden, MA: Blackwell.
- Evans, G. W. (2006). Child development and the physical environment. *Annual Review of Psychology*, 57, 423–451. doi:10.1146/annurev.psych.57.102904.190057

- Knittel, C. R., Miller, D. L., & Sanders, N. J. (2011). *Caution, drivers! Children present: Traffic, pollution, and infant health* (NBER Working Paper No. 17222). Cambridge, MA: National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w17222>
- Nilsson, P. J. (2009). *The long-term effects of early childhood lead exposure: Evidence from the phase-out of leaded gasoline* (IFAU Working Paper). Uppsala, Sweden: Institute for Labour Market Policy Evaluation. Retrieved from http://www2.vwl.uni-mannheim.de/fileadmin/user_upload/avh-seminar/Peter_Nilsson.pdf
- Parker, J., Mendola, P., & Woodruff, T. (2008). Preterm birth after the Utah Valley steel mill closure: A natural experiment. *Epidemiology*, *19*, 820–823. doi:10.1097/EDE.0b013e3181883d5d.
- Rauch, S. A., & Lanphear, B. P. (2012). Prevention of disability in children: Elevating the role of environment. *The Future of Children*, *22*, 193–209. Retrieved from http://futureofchildren.org/futureofchildren/publications/docs/22_01_09.pdf
- Rauh, V. A., Garfinkel, R., Perera, F. P., Andrews, H. F., Hoepner, L., Barr, D. B., ... Whyatt, R. W. (2006). Impact of prenatal chlorpyrifos exposure on neurodevelopment in the first 3 years of life among inner-city children. *Pediatrics*, *118*, e1845–e1859. doi:10.1542/peds.2006-0338
- Sanders, N. (2010). What doesn't kill you makes you weaker: Prenatal pollution exposure and educational outcomes. *Journal of Human Resources*, *47*, 826–850. Retrieved from <http://jhr.uwpress.org/content/47/3/826.full.pdf+html>
- U.S. Centers for Disease Control and Prevention. (2009). *Fourth national report on human exposure to environmental chemicals* (Discussion Paper). Washington, DC: Department of Health and Human Services.
- U.S. Government Accountability Office. (2009). *Observations on improving the Toxic Substance Control Act*. Testimony before the Committee on Environment and Public Works, U.S. Senate.
- U.S. Environmental Protection Agency. (2006, May). *Guideline for Reporting Daily Air Quality—Air Quality Index (AQI)* (EPA-454-06-001). Washington, DC: Author. Retrieved from <http://www.epa.gov/ttn/oarpg/t1/memoranda/rg701.pdf>
- Walker, S. P., Wachs, T. D., Grantham-McGregor, S., Black, M. M., Nelson, C. A., Huffman, S. L., ... Richter, L. (2011). Inequality in early childhood: Risk and protective factors for early child development. *The Lancet*, *378*, 1325–1338. doi:10.1016/S0140-6736(11)60555-2