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ABSTRACT

Can Pollution Cause Poverty? The Effects of Pollution on Educational, Health and Economic Outcomes*

Although industrial plants, known as Toxic Release Inventory (TRI) sites, exist in every major city of the United States releasing billions of pounds of toxic substances annually, there is little evidence about how these pollutants might harm child development and children's long run outcomes. Using the detailed geocoded data that follows national representative cohorts of children born to the NLSY respondents over time with detailed information on families, locations, health, disability and labor market outcomes, I compare siblings who were gestating before versus after a TRI site opened or closed within one mile of their home. In other words, I compare siblings in the same family whose family does not move between births where one or more child was exposed to TRI pollution during gestation and other siblings were not exposed because the plant opened or closed in between the conceptions of different children in the same family. I find that children who were exposed prenatally to TRI pollution have lower wages, are more likely to be in poverty as adults, have fewer years of completed education, are less likely to graduate high school, and are more likely to have a disability.

JEL Classification: Q53, I24, I14

Keywords: air pollution, academic achievement, child health

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I. Introduction

Billions of pounds of toxic substances are released each year, yet little is known about whether exposure to these pollutants might harm children's long run health, educational and labor market outcomes. In 2017, Toxic Release Inventory (TRI) sites alone (which represent only one type of industrial plant) released 3.97 billion pounds of (untreated) toxic chemicals in America into the air, land and water, out of 30.57 billion total pounds of toxic chemicals created in production-related wastes (EPA 2017). Tens of thousands of known toxic chemicals are used by industries and businesses in the United States to make common products, such as pharmaceuticals, furniture, and automobiles. While most toxic chemicals are managed so that they are not released into the environment, some release of these chemicals is the inevitable byproduct of manufacturing. There are currently about 21,800 TRI sites operating across the United States and 221,501,216 people had a TRI site operating in their zip code in 2016.[1] The Environmental Protection Agency estimates that 59 million people (about 19 percent of the population) live within one mile of an operating TRI site (EPA 2014).

In addition, there are reasons to believe that not all pollution is equally bad for human health and development. For example, TRI sites release known neurotoxins, such as lead and mercury, into the air. While criteria air pollutants (for example, particulate matter) have been regulated for decades, little is known about the effects of most of the chemicals released by TRI facilities. Most of the chemicals emitted have never undergone any kind of toxicity testing (US Department of Health and Human Services 2010) and were essentially unregulated until 2011 when the U.S. introduced the Mercury and Air Toxic Standards. These regulations are now being

[1] I made this calculation based on linking zip code level census counts of the population to TRI data.

contested.[2] Nevertheless, a growing literature suggests that airborne toxic pollutants from TRI sites can cause negative academic and behavioral outcomes for children in school (Persico and Venator 2019), cause cancer, harm birth outcomes (Currie, Davis, Greenstone and Walker 2015), and harm the brain and reproductive systems (Centers for Disease Control and Prevention 2009).[3] However, contemporaneous measures of pollution might underestimate the total welfare effects of environmental toxicants if these toxicants negatively affect the developing brain, and consequently, long-run outcomes.

This paper provides some of the first evidence that prenatal exposure to industrial pollution can cause negative long-run human capital outcomes with important distributional consequences. This paper is also the first to investigate how pollution might affect wages in adulthood through both health and educational channels. I use very detailed data from surveys of the children of the National Longitudinal Survey of Youth 1979 (NLSY79) and their parents that allows the matching of siblings and geographic information on families to examine how TRI pollution affects children's long run outcomes. By leveraging TRI plant openings and closings, I compare siblings within the same family in which one sibling was exposed to TRI pollution during gestation and the other was not exposed because the plant had not opened yet or because it closed before a later child was conceived. I consider two different approaches – comparing siblings who do not move away from close proximity to a TRI site and estimating an intent-to-treat (ITT) model that assigns initial TRI proximity and open/close dates to all siblings in the same family regardless of whether or not the family moved. By exploiting the short distance over which TRI toxicants can travel through air (i.e., one mile) and using within-family comparisons,

[2] The Supreme Court of the United States decided against the MATS rule in 2015 for lack of sufficient cost-benefit analysis and has remanded the case to the U.S. Court of Appeals.
[3] However, most of the evidence we have on the neurotoxic effects of these pollutants is from studies using animal models.

I am able to isolate the effects of pollution from other difficult-to-observe and possibly endogenous factors, such as local sorting, avoidance behavior, and time-invariant characteristics of families that happen to be near a TRI site that could affect child outcomes.

The consequences of prenatal exposure to TRI pollution are stark. I find that children who were gestating near an operating TRI site have 27.8 percent lower wages and are 15.6 percentage points more likely to be on a public assistance program as an adult than their sibling, who was not exposed to the TRI pollution. This represents a huge increase of 50.3 percent in public assistance use above the mean. In addition, children who are prenatally exposed to TRI pollution have 1.252 fewer years of education, are 13.9 percentage points less likely to graduate high school and are 9.3 percentage points more likely to have a cognitive disability as an adult than their sibling who was not prenatally exposed to pollution. I also find significant effects of prenatal exposure to TRI pollution, between -0.257 and -0.619 standard deviations, on a summary index of long-term outcomes.

These findings are much larger than previous estimates of the effect of pollution on wages (e.g., Isen et al 2017), and imply two possible explanations. First, prenatal exposure to TRI pollution, which contains known neurotoxins like lead and mercury, might be much worse than exposure to typical air pollution. Second, there might be important distributional consequences for exposure to pollution. Since disadvantaged families are more likely to live closer to TRI sites, exposure to pollution might push families without resources to compensate into poverty. The results are robust to a variety of specifications and suggest that pollution is a major channel through which inequality is reproduced.

II. Background

Research on the effects of pollution on children most commonly focuses on the link between exposure and health outcomes, such as birth weight, mortality or the prevalence of respiratory diseases for children in highly polluted areas.[4] There is some evidence that environmental toxicants might interact with genetic susceptibilities to alter developmental trajectories and produce cognitive disabilities, such as specific learning disabilities, speech and language impairments, intellectual disability, and autism (Miodovnik, 2011; Jurewicz et al, 2013). While cognitive disabilities may have a substantial underlying genetic component, there is also evidence that the development of cognitive disabilities is strongly influenced by the environment (Miller and McCardle, 2011). Recent research further points to the ways that genes are especially susceptible to environmental context, since genes are always stored, transcribed and translated within an environment that may influence these processes. Early-life epigenetic changes can also affect subsequent gene expression in the brain (Kundakovic. 2011; Roth, 2012; Green, 2015). There is also a growing body of evidence that during the prenatal, perinatal and early postnatal periods, as well as in early childhood, the developing human brain is highly vulnerable to toxic chemical exposures (Bearer, 1995; Rice and Barone Jr, 2000). During these sensitive periods, chemicals can cause permanent brain injury at low levels of exposure that would have little or no harmful effects in an adult (Bearer, 1995; Grandjean and Landrigan, 2014). Increasing evidence points towards non-genetic, environmental exposures that are involved in causation of cognitive disabilities, in some cases by interacting with genetically inherited risk factors and epigenetic mechanisms.[5]

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[4] For an overview of how in utero and early life exposure to negative environmental factors, such as pollution, can impact later life outcomes, see Almond and Currie (2011).

[5] For a more in-depth discussion of how different types of environmental toxicants affect cognitive development, please see the NBER working paper version of this paper (Persico et al., 2016).

Unfortunately, there are no studies to date comparing the effects of different types of toxicants on cognitive outcomes, though there is a literature showing the different types of toxicants can harm cognitive development in children. In a recent study, Aizer and colleagues (2015) found that a 5 micrograms per deciliter increase in children's preschool lead levels reduces elementary school test scores by 43 percent of a standard deviation. Lead reduction policies explained roughly half of the decline in the Black-White test score gap in these cohorts. Because lead easily crosses the blood-brain barrier, exposure to lead can lead to brain damage in the prefrontal cerebral cortex, hippocampus and cerebellum (Finkelstein, Markowitz, and Rosen, 1998).[6]

There is also evidence that other environmental toxicants found in TRI sites (e.g. methylmercury, arsenic, polychlorinated biphenyls, dioxin, volatile organic compounds, etc.) are similarly damaging to the developing brain, though there is far less research on these chemicals than on lead.[7] For example, there are growing epidemiological literatures on how exposure to TRI pollutants, such as Polycyclic Aromatic Hydrocarbons (PAHs) (Lovasi et al., 2014; Margolis et al., 2016; Perera et al., 2009), Volatile Organic Compounds (VOCs) (Allen et al., 2015; Grandjean & Landrigan, 2006; Wu, Bhanegaonkar, & Flowers, 2006), and other heavy metals (e.g., Bellinger, 2013; Ciesielski et al., 2012; Counter & Buchanan, 2004), might harm child development. However, epidemiological studies usually employ longitudinal methods that control for a range of variables and use the amount of a toxicant in a child's or mother's blood or

[6] The EPA (2013) provides a comprehensive review of hundreds of studies investigating the effects of lead from epidemiology, toxicology, economics, public health, neuroscience, and other disciplines. Early-life exposure to lead causes lower IQ, decreased test scores, increased rates of high school dropout, lower adult earnings, attention deficit disorders, impulsiveness, hyperactivity, conduct disorders, and criminal behavior.

[7] For reviews of the recent literature on how toxicants like methylmercury, arsenic, polychlorinated biphenyls, dioxin, volatile organic compounds, and other toxicants found in Superfund sites affect child development and the brain, see Bellinger (2013), Bose et al (2012), Grandjean and Landrigan (2006 and 2014), and Behrman, Butler and Outcomes (2007). Most of these toxicants have been tested in rat studies to show that they are neurotoxic, but the evidence on how they affect developing human brains is relatively small.

hair as a predictor of the effects of early toxic exposures. Often a disaster in which a large number of people were exposed to a large amount of the toxicant is used to detect the effects of the toxicant in humans. In some cases, epidemiologists use a comparison group of unexposed children. However, because of the nature of the research, there can be no random assignment, and there is often no data on the same outcomes before the disaster. Thus, it is difficult to control for pre-trends and account for possible biases using these methods.

However, a growing literature links pollution exposure during gestation to negative birth outcomes[8] and cognitive outcomes. For example, Persico, Figlio and Roth (2016) explore the effects of in utero exposure to Superfund pollution on health and cognitive outcomes in school, finding that pollution exposure is associated with worse infant health, 0.11 of a standard deviation lower test scores, and a higher likelihood of behavioral incidents, cognitive disabilities and repeating a grade. Ferrie, Rolf, and Troesken (2012) find that early exposure to lead affects later army intelligence test scores. Almond, Edlund, and Palme (2009) and Black et al (2013) use quasi-experimental designs and Scandinavian data and find effects of exposure to radiation from nuclear fallout during gestation on later test scores. Sanders (2012) finds that a standard deviation decrease in mean pollution level at birth is associated with 1.9 percent of a standard deviation increase in high school test scores in Texas. Bharadwaj, Gibson, Graff Zivin, and Neilson (2014) compare Chilean siblings' differential exposure to air pollution during gestation to show that exposure to carbon monoxide during the third trimester is associated with a 3 to 4 percent of a standard deviation decline in test scores in fourth grade.

[8] A growing literature has shown that children exposed in utero to pollution have higher infant mortality (Currie and Neidell, 2005), lower birth weight (Currie, Davis, Greenstone, and Walker, 2015), and a higher incidence of congenital anomalies (Currie, Greenstone, and Moretti, 2011). For example, a number of epidemiological studies have also found significant relationships between air pollution and preterm birth (Butler and Behrman, 2007).

Fewer papers, however, investigate the effects of pollution on later earnings. Black et al (2017) find effects on later earnings and educational attainment in Norwegian children exposed to radioactive fallout. Isen and colleagues (2017) compare cohorts of children in nonattainment counties that had to reduce their air pollution after the Clean Air Act to those in attainment counties. They find that cohorts exposed to more air pollution in early life is associated with a 0.7 percent decrease in the number of quarters worked and a one percent decrease in mean annual earnings. In a new working paper, Voorheis (2017) also finds that pollution exposure in early life is associated with modestly lower college attendance and wages.

Nevertheless, it is unclear what mechanisms might underly the relationship between pollution and long-run human capital outcomes and whether certain types of pollution might have bigger impacts on wages. In addition, this is the first paper to investigate the distributional consequences of prenatal pollution exposure on long-run outcomes. Finally, most studies to date are unable to account for time-invariant characteristics of families and neighborhoods that could affect child outcomes. This paper lends insight into the ways neighborhoods affect long-run outcomes for children, as well as the true costs of pollution.

III. Empirical Strategies

I evaluate the effects of in-utero exposure to environmental toxicants on children by comparing siblings who lived within 1 mile of a TRI site that opened or closed so that at least one sibling was exposed during gestation, but the other was not. In my analyses, I concentrate on families residing within one mile of a TRI site because, as shown in Figure 1, TRI pollution does not travel much farther than a mile.[9] I employ two different identification strategies that both use a family fixed effects design. First, I compare siblings whose family does not move between

[9] A similar result was obtained by Persico and Venator (2019).

births where at least one child was prenatally exposed to TRI pollution because the mother lived within 1 mile of an operating TRI site. The comparison group in the regressions is siblings living in the same neighborhood at birth who are conceived at a time when a TRI site is not operating because it had not yet opened or it closed. My second comparison is an intent to treat (ITT) analysis where I account for potentially endogenous mobility by conditioning on the location of the first birth near a TRI site for all siblings in the same family born earlier or later, regardless of whether the family moved. In other words, I compare children conceived within one mile of an operating TRI site to their siblings that are conceived after the same site closed or before it opened, regardless of whether the mother remained in the proximity of the site. These results include the entire population of siblings for which one sibling was ever conceived while a TRI site was operating.

Because pollution exposure is not randomly distributed, it is important to account for the time invariant characteristics of families and neighborhoods that could affect child outcomes in adulthood. Thus, my identifying assumption is that the only thing that changed between conceptions of siblings was that the local TRI site closed or opened. Because the timing of TRI site openings and closings is plausibly unrelated to the timing of conception, comparing siblings who do not move should yield an unbiased estimate of the effect of exposure to TRI pollution during gestation. Later in the paper I describe a variety of the tests and specification checks that I undertake in order to determine the degree to which my results are internally valid.

My basic family fixed effects estimation is given by:

(1) $$Y_{ijt} = \beta_1 ClosestSiteWithinMileisOpen_{ijt} + X_{ijt} + \theta_j + \gamma_t + \varepsilon_{ijt}$$

Where Y_{ijt} is some outcome of a child *i* born to family *j* at time *t*. I determine whether prenatal exposure to TRI pollution affects a variety of long-run outcomes, including the log of wages, family income, the likelihood of being on public assistance as an adult,[10] years of education, the likelihood of graduating high school, college attendance, as well as a summary index of adult outcomes. β_1 is the coefficient of interest on $ClosestSiteWithinMileisOpen_{ijt}$, which is a dummy variable for whether a child was conceived while a TRI site was operating within one mile of their mother's residence. θ_j is a family fixed effect that is specific to the mother, γ_t is a birth year fixed effect, and X_{it} is a vector of child-specific control variables (i.e., gender, birth order fixed effects, birth month fixed effects, birth spacing, marital status, and age in the last survey wave in 2016). In addition, the models that analyze economic outcomes (such as wages and family income) use all available person-year observations for ages 20-45 and control for age of the economic outcome linearly, a quadratic in age and a cubic in age to avoid confounding life cycle and birth cohort effects. Because many individuals did not respond in some survey waves or were missing some adult outcomes, I weight my regressions by the inverse of the number of times an individual is observed in the adult survey data.[11] ε_{ijt} is an error term. Standard errors are clustered at the TRI site level.[12]

Since children who live near TRI sites are slightly more disadvantaged, as shown in Table 1, one might be concerned that other neighborhood factors might contribute to disparities in outcomes. My estimates also could be biased if there are unobserved factors affecting the outcomes of children within one mile of a TRI site that are correlated with a TRI site opening or closing. For example, when a TRI site opens, more motivated families might move away from a TRI site to escape the pollution. If there is substantial residential sorting around an opening or

[10] I define adulthood in this context as age 23 or older. I define public assistance receipt as the receipt of Supplemental Nutrition Assistance Program (SNAP, also known as food stamps), Temporary Assistance to Needy Families (TANF), Aid to Families with Dependent Children (AFDC), Women, Infants and Children (WIC), general cash assistance, or Supplemental Security Income (SSI). I do not include veteran's benefits, etc.
[11] These results are also robust to weighting by the inverse probability of responding to the adult survey.
[12] The results are also robust to clustering at the zip code level.

closing, another mechanism through which a TRI site opening might affect children is through peer effects. On the other hand, a factory opening might both increase pollution and also stimulate the local economy (Greenstone, Hornbeck and Moretti, 2010), meaning that the positive impacts of better economic conditions may cancel out any negative impacts that could arise from pollution exposure.

To address these concerns, in my preferred specification I compare children in the same family who do not change neighborhoods. In an additional specification, I compare children in the same family who do move, but instrument the location of the first TRI site and the associated opening and closing dates for all other siblings. I also restrict the analysis to children who only live within a mile of one TRI site (or fewer) at a time to ensure that treatment intensity was consistent across all children in the sample. I show that my results are robust to a variety of tests and specification checks in Section V.C. of the paper.

These results could also be biased towards zero if environmental toxicants mothers were exposed to through living near TRI sites affect children who are conceived after the site closes. Some research suggests that once exposed, environmental toxicants remain in a person's body for a long time, contributing to chemical body burden (Thornton et al., 2002; CDC, 2009). If environmental toxicants from local TRI sites stay in a mother's body for a long time, they could affect siblings who are conceived even after a TRI site has closed. My results might also be biased towards zero if there exists measurement error in the recorded timing of openings and closings. I use the earliest time when the company first filed its tax records or first started reporting to the TRI as the opening date and the latest time when the company last filed or stopped reporting as the closing date, but if the site was not emitting pollution at those times, children might not have been meaningfully exposed.

IV. Data Description

In this study, I explore the long-term effects of being exposed to TRI pollution by using a rich, longitudinal survey connecting mothers and children. The National Longitudinal Survey of Youth 1979 Cohort (NLSY79) is a nationally representative sample of adolescents who were 14 to 22 years old when they were first surveyed in 1979. The survey follows 12,686 young men and women, with annual interviews through 1994 and biennial interviews after that. The survey collects rich data about labor market participation, education, health, training, family formation and mobility. The Bureau of Labor Statistics began a separate survey of all children born to NLSY79 female respondents in 1986, the NLSY79 Children and Young Adult Surveys (CNLSY). This survey (the CNLSY) can be matched to the mother's information from the NLSY79 and contains information on each child on health, education, labor market participation, engagement in risky behaviors, and disability through 2016.

The set of adult outcomes I focus on include (1) labor market and economic status outcomes (measured biannually and expressed in 2000 dollars) – wages, family income[13] (20-45) and the incidence of poverty in adulthood (23-45), (2) educational outcomes – years of completed education, whether a person graduated high school, and whether a person attended college, and (3) health outcomes – the likelihood of having any disability[14] and the likelihood of having a cognitive disability.[15] Wages, defined by annual earnings/annual work hours, is my main labor market outcome. I compute wages for only those who have positive earnings in a given year, and valid data exists for 79 percent of the sample of children with siblings living

[13] If a person is not married, family income is equal to individual income.
[14] Having any disability is defined as reporting having a cognitive disability, epilepsy, a nervous disorder, a heart problem, cancer, or being handicapped.
[15] Having a cognitive disability is defined as having a learning disability, ADHD/hyperactive, intellectual disability or a speech impairment.

within one mile of a TRI site.[16] The average wage (in 2000 dollars) at age 30 for the whole sample is $15.20.

To reduce measurement error and address concerns about multiple inference, I construct a summary index of outcome measures (Kling, Liebman, and Katz 2007; Deming 2009). I normalize each outcome to have a mean of zero and standard deviation of one, adjust the signs of outcomes so that a more positive outcome is better (i.e., I flip the sign for being on public assistance or having disabilities), and take the simple average across those outcomes. I then standardize the summary index, which includes family income, likelihood of being on public assistance programs as an adult, years of education, graduating high school, graduating college, having a cognitive disability, and being employed in the last four years.

I gathered data on the annual types of pollution released by TRI sites and the locations of TRI sites from the EPA. Because the toxic emissions measures in the TRI database have been widely criticized for containing substantial measurement errors,[17] I gathered data on the timing of TRI site opening and closings from the state tax filings. Companies that are operating are required to file taxes each year, and I was able to match TRI sites based on business names and address information. I use the time when the company first filed its tax records or started reporting to the TRI as the opening date and the time when the company last filed or stopped reporting as the closing date.[18]

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[16] I drop a few implausibly low wages that are lower than $2.75 per hour.

[17] The data on emissions is self-reported and based on criteria that have varied over time. The EPA does not require plants to measure their emissions precisely, or to report at all under certain circumstances. Facilities are required to report if they manufactured or processed more than 25,000 pounds of a listed chemical or "otherwise used" 10,000 pounds of a listed chemical. For persistent bio-accumulative toxins, the thresholds are lower. These thresholds have changed periodically over the life of the program. The EPA provides guidance about possible estimation methodologies, but plants estimate their emissions themselves. Estimating methodologies may vary between plants and over time (Currie, Davis, Greenstone and Walker, 2015).

[18] However, the first year of the TRI is 1987. If a company reported on the TRI in 1987, they could not be found in the tax records, and there was reason to believe it was operating before 1987, in a few cases I assigned its opening date as 1970. The results are also robust to the assignment of different opening dates.

Using geocoded census-tract and zip-code data from the NLSY79 and latitudinal and longitudinal coordinates for TRI sites, I calculate the closest distance to the nearest TRI sites in the year a child was born. The sample in this study includes every child born within one mile of a TRI site. 693 TRI sites opened and 497 sites closed between 1970 and 1998, the latest birth year for which I could observe adult outcomes. I also match these data to additional census tract and zip-code level census data from the 1980, 1990, 2000 and 2010 censuses. Table 1 presents the characteristics of children of NLSY79 respondents overall in Column 1, within one mile of a TRI site in Column 2 and within one mile of an open TRI site in Column 3. As shown in Table 1, children living within one mile of TRI site are significantly more disadvantaged than children in the CNLSY79 overall. Their mothers and fathers had fewer years of education at birth, were less likely to be married, and were more likely to report being in poverty than the entire sample of CNLSY79 children. They are also more likely to be Black or Hispanic, and less likely to attend preschool. However, children who were gestating near an open TRI site are similar to all other children who ever live near a TRI site on observable characteristics.

V. Long-run Outcomes of TRI Exposure During Gestation

A. Main Results

Table 2 presents the results that compare siblings with and without TRI pollution exposure during gestation on several long-run outcomes: an outcomes index, the log of wages, family income, being on public assistance as an adult, years of education, high school completion, and attending college. Panel A presents the results from my preferred specification that compares non-moving siblings.[19] It is important to note that the models that analyze

[19] The regressions are weighed by the inverse of the number of times an individual is observed in the adult survey data, and standard errors are clustered at the TRI site level.

economic outcomes (such as wages and family income) use all available observations for ages 20-45 and control for a cubic in age to avoid confounding life cycle and birth cohort effects (in addition to all of the other controls outlined in Section III). Standard errors are clustered at the TRI site level.

Being exposed to pollution prenatally is associated with large negative effects on long-run outcomes. I find a 0.619 of a standard deviation decline in the long-run outcomes index. Children who are exposed to TRI sites during gestation have 27.8 percent lower wages and are 15.6 percentage points more likely to be on public assistance as an adult than their siblings, which represents a whopping 50.3 percent increase above the mean. I also find that children who are exposed to TRI pollution prenatally have 1.252 fewer years of education and are 13.9 percentage points less likely to complete high school than their siblings. Given that 87.6 percent of all children in the nationally representative sample graduate from high school, this represents a 112 percent increase in dropping out of high school. However, I do not find a statistically significant effect on college attendance or family income, though the point estimates are negative.

The estimates in Panel B of Table 2 present the results of my ITT specification where I account for endogenous mobility by instrumenting for birth location with the first time a family lived near a TRI site, regardless of whether the family moved. In other words, I compare childing conceived within one mile of an operating TRI site to their siblings that are conceived when the same site is not operating, regardless of whether the mother remained in proximity of the site. The results are smaller since children might not have been prenatally exposed to TRI pollution if their family moved away between births, but they would be assigned as treated if the site was still open. Nevertheless, I find that being prenatally exposed to TRI pollution leads to a 0.257

percent of a standard deviation decline in the long-run outcomes index compared to their siblings. I also find that children prenatally exposed to TRI pollution have family incomes that are $8,209 lower. They also complete 0.563 fewer years of education and are 8.5 percentage points less likely to complete high school than their siblings who were not prenatally exposed to TRI pollution.

Table 3 presents some additional long run outcomes that could constitute other mechanisms through which TRI pollution affects long run outcomes. While the effect of being exposed to a TRI site prenatally on being employed in either of the last two survey waves (in 2014 or 2016) or ever receiving unemployment is not statistically significant, the direction of the estimates suggest that unemployment might partially drive these effects.[20] In addition, I find a suggestive increase in ever reporting ever being convicted, on probation or in prison for children who were prenatally exposed to TRI pollution. However, these outcomes are not statistically significant at the 10 percent level.

I also find that children who were exposed to TRI pollution prenatally are more likely to have ever been married, even though they have lower family income. Children exposed to TRI pollution prenatally are also 7.4 percentage points more likely to have any disability and 9.3 percentage points more likely to have a cognitive disability than their siblings.[21] This represents a 148 percent increase in disability rates overall and a massive 258 percent increase in cognitive disabilities. The point estimates also imply that cognitive disabilities drive the results on disability.

[20] I find no effects on being employed full time or part time.

[21] Because there could be differential slippage between these categories over time, I examine cognitive disabilities separately and together.

The picture that emerges suggests that pollution exposure during gestation is associated with having a cognitive disability, dropping out of high school, and then being on public assistance. One reason the effects might be so large is that TRI sites are known to emit especially harmful classes of compounds, such as heavy metals, volatile organic compounds and polycyclic aromatic hydrocarbons. There is currently little causal research in humans about what these might do to the developing human brain, largely because this topic is difficult to study.

Next, I examine whether TRI site openings might have different effects from TRI site closings. One might expect TRI site closings to produce larger effects than openings since in the case of closings, only one sibling is exposed to TRI pollution, while in the case of openings, both siblings are exposed to the pollution, but at different ages. The results are presented in Table 4, where Panel A presents the effects for a TRI site opening on long-run outcomes and Panel B presents the effects for a TRI site closing on outcomes. Both specifications use the sample of non-moving families and compare siblings. The results in Table 4 suggest that for the long-run outcomes index and years of education, the effects of a closing are slightly larger than that of an opening. However, the pattern of results for openings and closings are fairly similar, which suggests that prenatal exposure to TRI pollution is worse than exposure at other times.

B. Heterogeneity of Estimated Effects

Table 5 presents estimates of the effects of exposure to TRI pollution by gender and socioeconomic status. Panel A presents the results for boys, while Panel B presents the results for girls. Overall, exposure to TRI pollution has somewhat worse effects for girls than for boys. Girls who were prenatally exposed to TRI pollution have fewer years of completed education (1.621 fewer years of education for girls, compared with 0.957 fewer years for boys), and are much less likely to complete high school. Girls who are exposed to TRI pollution are 18.9

percentage points less likely to complete high school compared with their unexposed siblings. The outcomes index is -0.641 for girls, compared with -0.605 for boys. However, the likelihood of being in poverty in adulthood is similar for girls and boys who were exposed to pollution.

Panel C of Table 4 presents the results for children whose mothers were not in poverty when they were born, and Panel D presents the results for low-income children whose mothers were in poverty when they were born. The effects of prenatal exposure to TRI pollution are also much larger in magnitude for low-income children than for higher income children. Low-income children who suffered prenatal pollution exposure have 1.627 fewer years of education and are 23.5 percentage points less likely to complete high school than their siblings. They are also 19 percentage points less likely to attend college than their unexposed sibling. In comparison, wealthier children have 1.03 fewer years of education, are 10.4 percentage points less likely to complete high school than their siblings. The outcomes index is -0.397 for non-poor children and -1.189 for low-income children, which is a very large disparity overall. This may be because low-income children live in closer proximity to the TRI pollution than wealthier children. However, the pattern of findings also suggest that pollution harms intergenerational mobility and might push people at the margins of poverty into poverty.

Panels E and F present the results by race: Panel E shows the results for non-Hispanic White children and Panel F shows the results for Black and Hispanic children.[22] Overall, the results are similar across racial groups. However, the effects of prenatal exposure to TRI pollution on public assistance are larger for Black and Hispanic adults, while the effects on high school completion is higher for non-Hispanic White individuals. Overall, the long-run outcomes index suggests that the effects are larger overall for Black and Hispanic individuals.

[22] Unfortunately, due to sample size constraints, the effects on Black and Hispanic children had to be estimated as one group.

In Table 6, I present the results of an exploratory analysis in which I estimate the effects of pollution on children for TRI sites that report emitting pollution through stacks, compared with TRI sites that have fugitive emissions. Because pollution released through smokestacks is usually treated with scrubbers before being released, one might expect the results to be smaller in magnitude for stack releases than for fugitive releases, which are essentially untreated releases. All specifications maintain the family fixed effects model and only include non-movers. The results presented in Panels A and B of Table 6 show that the pattern for stack releases and fugitive releases is quite similar overall. However, the effects on wages in adulthood and years of education are larger for fugitive releases, but not for stack releases.[23]

C. Additional Threats to Internal Validity

One alternative explanation for these findings is that family income, a mother's marital status, a mother's or father's education, prenatal care, or parental behavior may have changed between siblings so that children born when TRI sites were not operating experienced married parents or parents with higher education and more resources than siblings born during a TRI site operating. While I do not have data on all factors that might have changed within families, I test for this directly in Table 7 by comparing years of maternal and paternal education and whether the mother was married, reported at birth, between siblings who were exposed to TRI pollution, relative to siblings who were conceived after a site closed or before it opened. I also compare total years of childhood poverty, the month prenatal care was first obtained, whether the mother smoked or drank during pregnancy, and where a child ever attended preschool between siblings

[23] Because the EPA only includes data on stack vs fugitive releases for a subsample of TRI sites, the number of observations are smaller here than for the full sample. Sites with missing data on stack versus fugitive releases are treated as missing, though it is clear they released air pollution. The EPA defines fugitive emissions as unintended emissions from facilities or activities (e.g., construction) that "could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening" (see title 40 of the Code of Federal Regulations, sections 70.2 and 71.2). Thus, it might be the case that only the milder polluters volunteer this information. In addition, many sites release both stack and fugitive releases, making disambiguating the effects difficult.

who were exposed to the TRI pollution, compared with their unexposed siblings. The results, presented in Table 7, are not statistically significant at the 10 percent level. In Table A1, I show the results additionally controlling for maternal marriage status at the time of birth and total years of childhood poverty. The results are very similar to those presented in Table 2.

One might also be concerned that the closing of a TRI site might make a neighborhood more attractive to live in – and this neighborhood improvement, not the TRI site closing per se, was the cause of the better long-run outcomes. For example, if a TRI site's closure causes more educated and affluent people to enter a neighborhood, later born children might do better in school than their earlier born siblings because the composition of children in neighborhoods changed, leading to positive peer effects. While I do not have data on the schools children born to NLSY recipients attended, I can compare neighborhood characteristics between births. Using data from the 1980, 1990 and 2000 Censuses, I compare median home values, median income, percent of dwellings that are rented, the percent Black and percent Hispanic[24] at the zip code or census tract level for children prenatally exposed to TRI pollution, relative to their siblings who were not exposed in the same neighborhood. The results, presented in Table 8, show that siblings experienced roughly similar neighborhoods, with the exception that children who gestated when a TRI site was operating experienced neighborhoods where homes were 1 percentage point more likely to be owned, rather than rented. However, overall there are no economically meaningful differences in neighborhood characteristics between the neighborhoods siblings experienced. This makes sense since the average gap between siblings is roughly 3 years. In addition, Persico and Venator (2019) find that there is no differential sorting based on observable characteristics into or out of schools after the openings or closings of TRI sites.

[24] I linearly interpolate these values for missing years of data.

One might also be concerned that a few very polluted TRI sites are driving the results. Thus, Table 9 presents results that limit the types of TRI sites used in the analysis in two different ways. The results presented in Panel A are limited to those TRI sites that are emitting pollution below the 80^{th} percentile nationally. In other words, I drop the top 20 percent of polluters from the sample entirely and estimate the results for only the bottom four fifths of the distribution of TRI sites. The results presented in Panel B are from a sample of TRI sites that do not have bad-sounding names, or names associated with pollution.[25] The results in both Panels A and B are very similar to those in Table 2, suggesting that it is not negative selection into certain neighborhoods or especially bad TRI polluters that drive the results. In addition, the results in Panel A show that prenatal exposure to TRI pollution lowers the likelihood that a child will attend college, compared to their unexposed siblings who was conceived before a TRI site opened or after it closed.

Finally, one might be worried that even though I control for birth spacing, birth order and birth month and year, that the results might be driven by children who are very different in birth order. Thus, in Table A2 I limit the sample to just children who are first or second born. The results are again very similar to those in Table 2, suggesting that birth order does not drive the results. In addition, I also estimate the effects of prenatal exposure to TRI sites using a difference in difference strategy in which I compare siblings where one was exposed in utero to TRI pollution within one mile of a TRI site to the same contrast for families living eight to ten miles away from a TRI site.[26] The results, presented in Table A3, are quite similar to the main results

[25] Bad-sounding names were names that included the words "industry", "concrete", "metal", "chemical", "pharmaceutical", "plastic", "manufacturing" or "power plant." I also flagged any names that sounded like something one would avoid living near, like oil refineries, landfills, recyclers or industrial names.
[26] This specification has the advantage of estimating birth order effects more cleanly, as well as accounting for time trends.

in Table 2, suggesting that time trends over this time period and birth order do not substantially affect the results.

VI. Conclusion

This is the first study to examine the long-run effects of living near industrial pollution on wages, family income, adult poverty, years of education, high school completion and the development of cognitive and other disabilities. Children prenatally exposed to TRI pollution have 28% lower wages, a 50.3 percent increase in the likelihood of being on public assistance as an adult, have 1.252 fewer years of education, and have a 112 percent increase in dropping out of high school, relative to their siblings who were not exposed during gestation. They also have a 148 percent increase in disability rates overall, as well as a staggering 258 percent increase in cognitive disabilities. The results suggest that early life exposure to industrial pollution contributes substantially to long-term cognitive, labor market and developmental outcomes, and that pollution has much higher costs than have previously been estimated. In addition, closing TRI sites substantially benefits children's cognitive development and long-run labor market and health outcomes.

While it is difficult to estimate the total costs of TRI pollution because of potential differences across samples, I attempt a rough back of the envelope calculation to estimate the cost of TRI pollution on the costs of providing public assistance for one year. The federal government spent $877.5 billion on benefits and services for people with low income in 2016 (Falk, Lynch and Tollestrup 2018), and there were about 39.7 million low-income people in poverty (Fontenot, Semega and Kollar 2018). This implies a total average benefit cost of $22,103.3 per person on food, housing, medical care, job training and the like. Given that 19 percent of the U.S. population live within one mile of a TRI site (EPA 2014) and there were

3,941,109 children born in 2016 (CDC 2016), this implies an additional cost of about $2.58 billion per birth cohort per year from TRI pollution.[27]

Because exposure to pollution might have distributional effects, pushing people on the margins into poverty and disability, the true costs of pollution might be quite high. In addition, the results suggest that prenatal exposure to TRI pollution, which contains known neurotoxins like lead and mercury, might be much worse than exposure to typical air pollution. Given that geography is an important determinant of human capital formation (Chetty, Hendren, Kline and Saez, 2014), it is important to understand the mechanisms behind the disparities in educational outcomes that could stem from location itself. This study shows that one important mechanism through which neighborhoods affect long run outcomes is through exposure to industrial pollution.

I find strong evidence of worse outcomes even though the comparison set of siblings are likely exposed to some pollution, particularly in the case where there is a TRI opening. In addition, I find large effects even though some parents might practice avoidance behaviors to reduce children's exposure to pollution. However, these findings might also reflect the effects of cumulative exposure to environmental toxicants, since some children may live near a TRI site for a long time before it closes or after it opens.

Nevertheless, my findings point toward the notion that regulating TRI pollution would benefit low income communities substantially, since children born to mothers living near sources of pollution are negatively affected in terms of their cognitive development and long-run outcomes. In addition, Black, Hispanic, and low-income children are nearly twice as likely to live within one mile of a TRI site as the average for all children in the sample. The fact that low-

[27] This calculation uses the estimate in column 2 of Table 2 (0.156) to estimate the additional fraction of people who would need public assistance.

income, Black, and Hispanic children are more likely to be exposed to environmental toxicants has profound implications for environmental justice and residential segregation. If TRI sites negatively affect housing values (Currie, Davis, Greenstone, & Walker, 2015) and poor children are almost twice as likely to live nearby, exposure to industrial pollution might also partially explain the widening socioeconomic education gap (GAO 2019). Pollution exposure could also be partially responsible for low-income children having a higher incidence of cognitive disabilities than higher income children (Bloom, Jones, and Freeman, 2013).[28]

Unfortunately, my results do not speak to specific toxicants to which individuals were exposed, since exposure to different compounds and agents released by TRI sites are collinear – TRI pollution is a mixed treatment. Further research is also needed to address how the benefits of TRI regulation may vary across industries and types of pollution, as well as what schools and other programs can do to support children with early toxic exposures.

However, this study is among the first to provide insights into how environmental pollution and policies affect early development and long run human capital outcomes. In particular, this is the first paper to examine whether exposure to especially harmful pollution affects adult wages, poverty, education and disability. In addition, this work speaks to how residential and socioeconomic contexts contribute to children's unequal life chances. If some pollution has distributional consequences that push people into poverty, it might be far more costly to families and society than previously supposed.

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[28] In families with an income of less than $35,000, the percentage of children with a learning disability (11 percent) is almost twice that of children in families with an income of $100,000 or more (6 percent) (CDC, 2013).

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Tables

Table 1: Characteristics of Children Within One Mile of a TRI site

	(1) Characteristics of all Children in the NLSY	(2) Characteristics of Children Within 1 Mile of a TRI Site	(3) Characteristics of Children Within 1 Mile of an Open TRI Site
Maternal Education at Birth	12.87	12.14	12.19
Paternal Education at Birth	12.64	12.20	12.35
Mother was in Poverty in Birth Year	0.168	0.279	0.284
Years of Education in Adulthood	13.69	13.05	13.21
Percent Black	0.157	0.295	0.274
Percent Hispanic	0.080	0.161	0.179
Maternal Marriage Status	0.744	0.569	0.562
Attended Preschool	0.662	0.599	0.587
Observations	11,521	2,138	1,014

Note: This table depicts the characteristics of children in the sample. Column 1 shows the characteristics of all CNLSY79 individuals using sample weights. Column 2 shows characteristics of all children within one mile of a TRI site. Column 3 shows characteristics for all children within one mile of an operating TRI site.

Table 2: Long-Run Outcomes with Family Fixed Effects for Children Conceived Within One Mile of a TRI site

	(1) Outcomes Index	(2) Log Wages	(3) Family Income	(4) On Public Assistance	(5) Years of Education	(6) Completed High School	(7) Attended College
	Panel A: Restricted to Non-Moving Families						
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.619***	-0.278*	-493.71	0.156**	-1.252***	-0.139**	-0.062
	(0.185)	(0.149)	(4,694.95)	(0.078)	(0.429)	(0.056)	(0.069)
Observations	1,207	972	1,079	1,295	1,138	1,235	1,217
	Panel B: Intent to Treat						
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.257**	-0.106	-8,209.05**	0.057	-0.563**	-0.085**	-0.004
	(0.113)	(0.082)	(3,309.94)	(0.056)	(0.236)	(0.040)	(0.055)
Observations	1,310	1,032	1,154	1,362	1,220	1,347	1,330
Average of dependent variable	0	2.371	31,454	0.310	13.69	0.876	0.683

Note: Columns 1-7 present the results for different long-run outcome variables. In Panel A, only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. The estimates in Panel B are from the Intent to Treat specification. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 3: Mechanisms and Other Long-Run Outcomes

	(1) Employed (in Either of the Last 2 Surveys)	(2) Ever on Unemployment	(3) Ever Convicted, on Probation or in Prison	(4) Was Ever Married	(5) Has a Disability	(6) Has a Cognitive Disability
Conceived when TRI Site is Open	-0.112	0.018	0.037	0.096**	0.074*	0.093**
(Compared to Conceived When TRI was Closed)	(0.091)	(0.020)	(0.067)	(0.039)	(0.040)	(0.047)
Observations	1,435	1,514	1,514	1,460	1,530	1,530
Average of dependent variable	0.626	0.071	0.185	0.256	0.050	0.036

Note: Columns 1-6 present the results for different long-run outcome variables. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 4: The Effects of Openings versus Closings on Long-Run Outcomes with Family Fixed Effects for Non-Moving Children Conceived Within One Mile of a TRI site

	(1) Outcomes Index	(2) Log Wages	(4) On Public Assistance	(5) Years of Education	(6) Completed High School	(6) Attended College
	Panel A: Restricted to Openings					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.668***	-0.199	0.157*	-1.523***	-0.163***	-0.084
	(0.194)	(0.147)	(0.083)	(0.390)	(0.056)	(0.069)
Observations	1,195	963	1,285	1,127	1,223	1,205
	Panel B: Restricted to Closings					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.883***	0.094	0.196	-2.393***	-0.129	-0.163
	(0.319)	(0.264)	(0.163)	(0.724)	(0.080)	(0.129)
Observations	1,138	911	1,226	1,075	1,163	1,147
Average of dependent variable	0	0.316	0.876	0.698	0.050	0.050

Note: Columns 1-6 present the results for different long-run outcome variables. In Panel A, I restrict to TRI site openings and in Panel B I restrict to TRI site closings. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 5: Long-Run Outcomes by Gender, Race and Poverty Status at Birth

	(1) Outcomes Index	(2) Log Wages	(3) On Public Assistance	(4) Years of Education	(5) Completed High School	(6) Attended College
	Panel A: Boys					
Conceived when TRI Site is	-0.605***	-0.280*	0.154*	-0.957**	-0.109*	-0.071
Open (Compared to Closed)	(0.207)	(0.158)	(0.083)	(0.458)	(0.066)	(0.078)
	Panel B: Girls					
Conceived when TRI Site is	-0.641***	-0.275	0.156*	-1.621***	-0.189***	-0.050
Open (Compared to Closed)	(0.193)	(0.175)	(0.082)	(0.489)	(0.049)	(0.082)
	Panel C: Non-Poor Children					
Conceived when TRI Site is	-0.397**	-0.297*	0.154	-1.033**	-0.104**	-0.014
Open (Compared to Closed)	(0.162)	(0.154)	(0.094)	(0.472)	(0.052)	(0.077)
	Panel D: Low-Income Children					
Conceived when TRI Site is	-1.189***	-0.105	0.151*	-1.627***	0.235**	-0.190*
Open (Compared to Closed)	(0.335)	(0.205)	(0.085)	(0.563)	(0.109)	(0.111)
	Panel E: Non-Hispanic White Children					
Conceived when TRI Site is	-0.481*	-0.259	0.126	-1.164	-0.172*	-0.025
Open (Compared to Closed)	(0.264)	(0.214)	(0.098)	(0.766)	(0.010)	(0.142)
	Panel F: Black and Hispanic Children					
Conceived when TRI Site is	-0.500**	-0.161	0.200*	-0.561	-0.096	-0.075
Open (Compared to Closed)	(0.238)	(0.163)	(0.102)	(0.485)	(0.061)	(0.093)
Observations	1,207	972	1,295	1,138	1,235	1,217
Average of dependent variable	0	0.316	0.876	0.698	0.050	0.050

Note: Columns 1-6 present the results for different long-run outcome variables. In Panels A and B, I estimate the effects by gender, and in Panels C and D I examine whether the results vary by maternal poverty status in a child's birth year. Panels E and F estimate the effects by race. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 6: Long-Run Outcomes by Treatment Intensity

	(1) Outcomes Index	(2) Log Wages	(4) On Public Assistance	(5) Years of Education	(6) Completed High School	(6) Attended College
	Panel A: Stack Releases					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.859**	0.015	0.233	-0.663	-0.275*	-0.275*
	(0.406)	(0.188)	(0.143)	(0.696)	(0.152)	(0.152)
Observations	764	635	706	682	757	757
	Panel B: Fugitive Releases					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.544***	-0.354**	0.139	-1.285**	-0.107**	-0.107**
	(0.192)	(0.170)	(0.086)	(0.514)	(0.053)	(0.053)
Observations	923	782	859	837	913	913
Average of dependent variable	0	0.316	0.876	0.698	0.050	0.050

Note: Columns 1-6 present the results for different long-run outcome variables. In Panel A, I restrict to TRI sites reporting stack releases and in Panel B I restrict to TRI sites with fugitive releases. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 7: Average Difference in Family Characteristics between Siblings Living Within 1 Mile of a TRI Site

	(1) Maternal Marriage Status	(2) Years of Maternal Education	(3) Years of Paternal Education	(4) Poverty Status in Birth Year	(5) Total Years of Childhood Poverty	(6) First Month Prenatal Care Was Obtained	(7) Mother Smoked During Pregnancy	(8) Mother Drank During Pregnancy	(9) Ever Attended Preschool
Conceived when TRI Site Is Open (Compared to Conceived When TRI was Closed)	0.051 (0.036)	-0.090 (0.175)	0.430 (0.369)	0.054 (0.073)	0.243 (0.332)	0.512 (0.434)	0.059 (0.064)	0.048 (0.096)	-0.054 (0.081)
Observations	1,480	1,137	497	1,530	1,530	1,348	1,530	1,530	1,396
Average of Dependent Variable	0.744	12.87	12.64	0.168	2.18	2.42	0.214	0.404	0.662

Note: Columns 1-9 present the results for running my main specification where the outcomes are different family characteristics. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 8: Average Difference in in Zip-code level Characteristics between Siblings Living Within 1 Mile of a TRI Site

	(1) Median Home Value	(2) Median Household Income	(3) Percent Black	(4) Percent Hispanic	(5) Percent of Homes Rented
Conceived when TRI Site is Open	-43.432	43.705	-0.009	0.003	-0.011***
(Compared to Conceived When TRI was Closed)	(1,569.301)	(287.993)	(0.009)	(0.011)	(0.003)
Observations	1,386	1,386	1,386	1,386	1,386

Note: Columns 1-9 present the results for running my main specification where the outcomes are different zip code characteristics. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

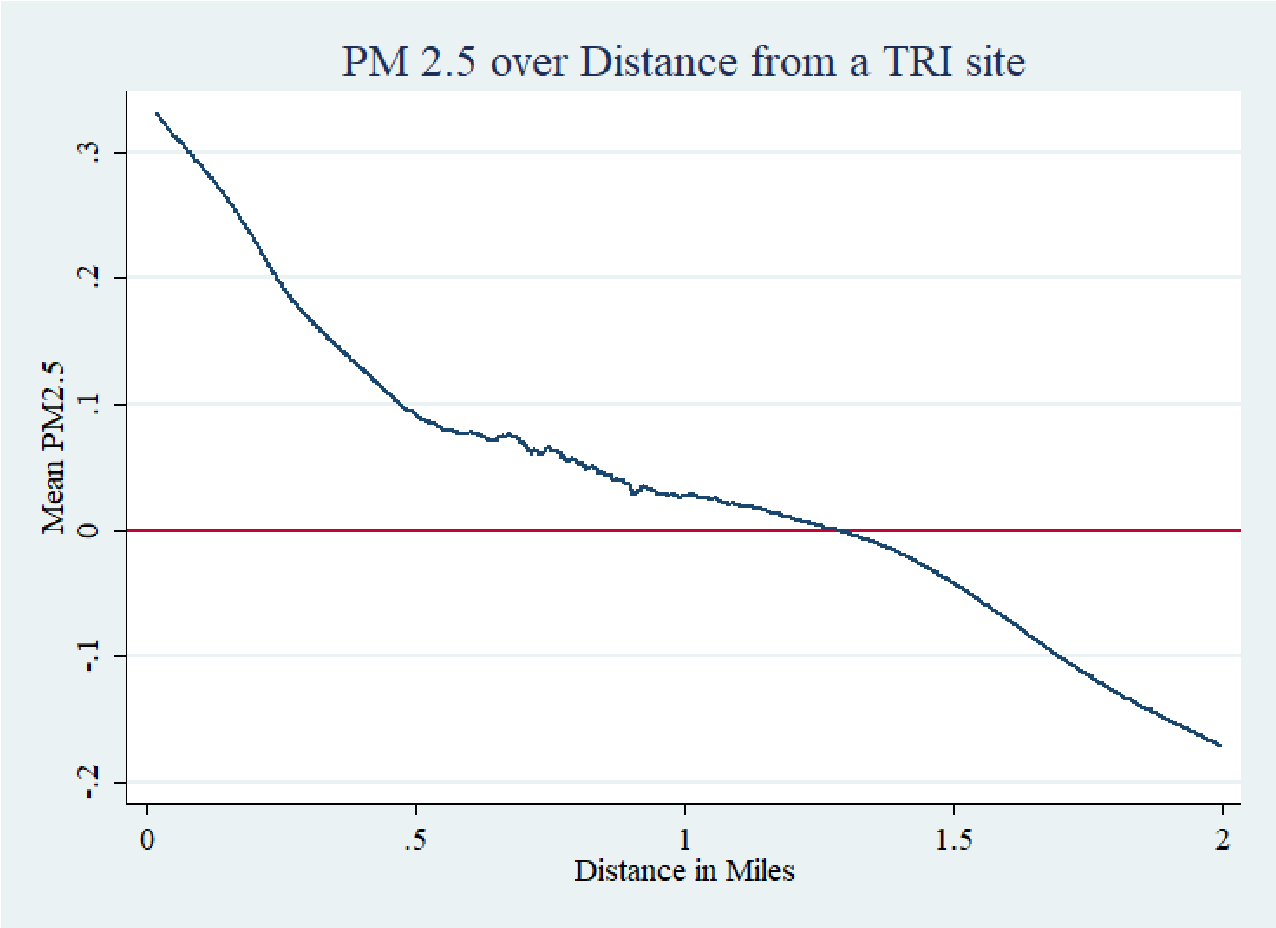
Table 9: Long-Run Outcomes with Family Fixed Effects for Children Conceived Within One Mile of a TRI site, Limiting to TRI Sites with Pollution Below the 80th Percentile for TRI Sites Nationally or Without Bad-Sounding Names

	(1) Outcomes Index	(2) Log Wages	(4) On Public Assistance	(5) Years of Education	(6) Completed High School	(6) Attended College
	Panel A: Limiting to TRI Sites with Pollution Below the 80th Percentile for TRI Sites Nationally					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.763***	-0.069	0.176**	-1.624***	-0.204***	-0.138**
	(0.228)	(0.166)	(0.076)	(0.362)	(0.064)	(0.068)
Observations	1,090	813	1,079	1,001	1,080	1,015
	Panel B: Limiting to TRI Sites without Bad-Sounding Names					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.732***	-0.223	0.133	-1.578***	-0.158**	-0.106
	(0.245)	(0.156)	(0.085)	(0.401)	(0.068)	(0.074)
Observations	1,041	832	1,115	982	1,065	1,049

Note: Columns 1-6 present the results for different long-run outcome variables. In Panel A, I restrict to TRI sites with pollution emissions that are below the 80th percentile nationally for TRI sites. In Panel B I restrict to TRI sites that do not have bad-sounding names. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

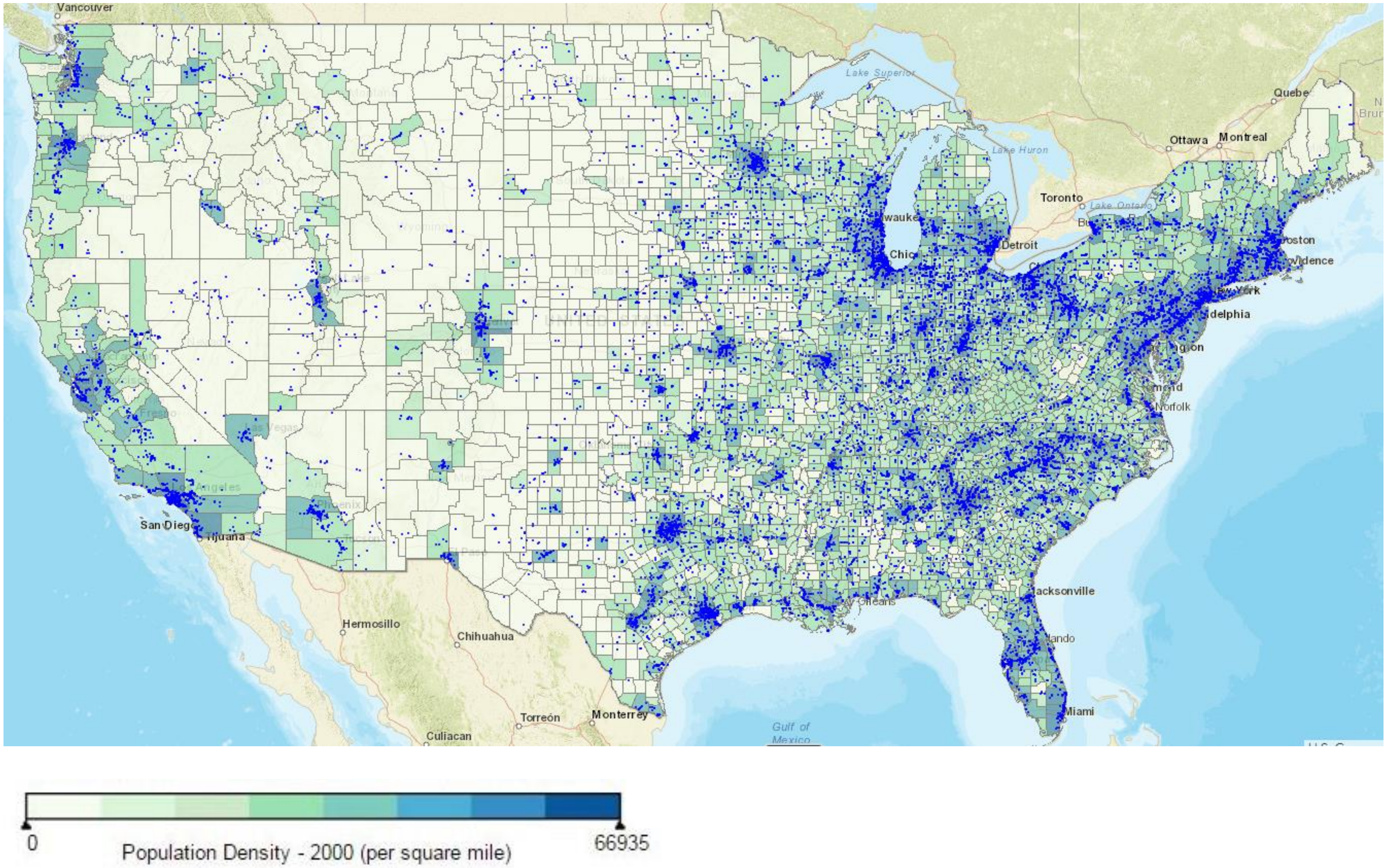
Figures

Figure 1: Particulate Matter 2.5 levels over Distance Away from a TRI site, Nationally



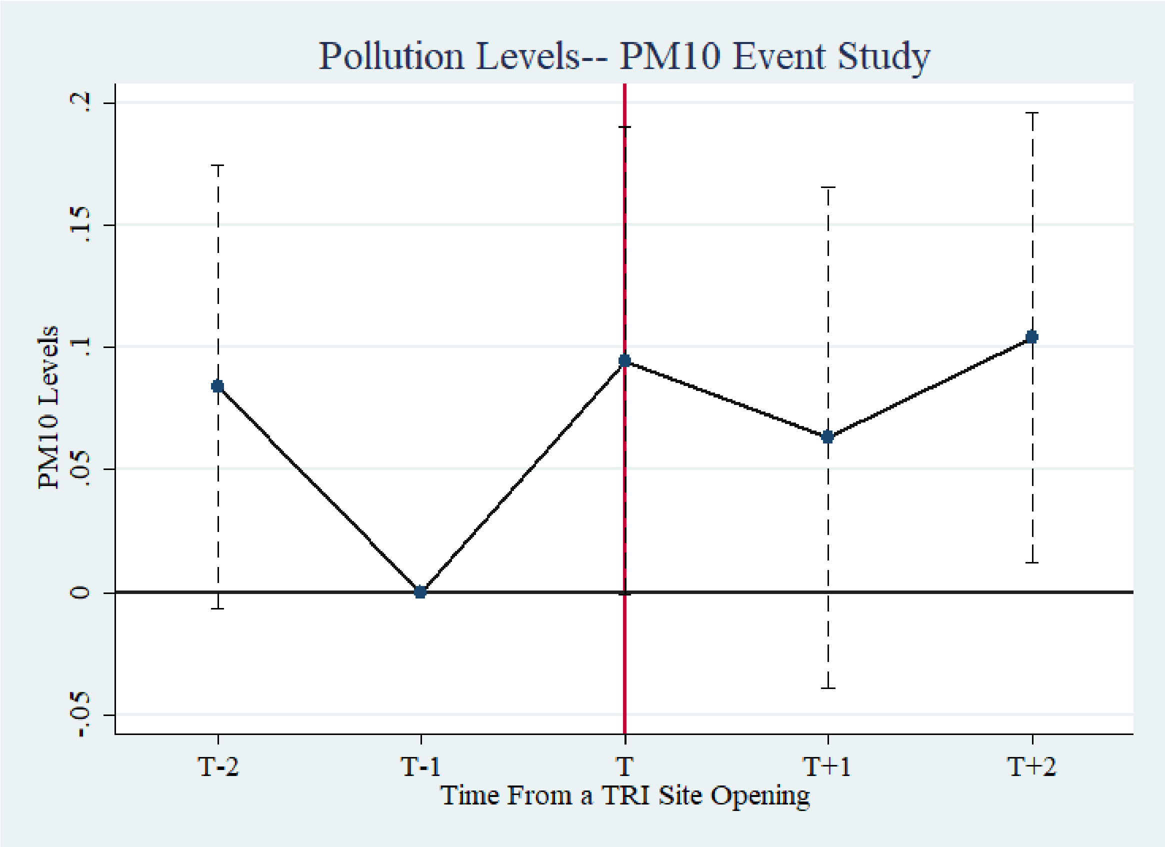
Note: Figure 1 depicts the level of Fine Particulate Matter (PM 2.5) over distance from the TRI site using data from 1990 to 2012. I show pollution levels by calculating the distance between PM 2.5 EPA monitors and the open TRI sites, regressing a locally weighted smoothed regression of the average PM2.5 measured at a monitor on distance from a TRI site.

Figure 2: TRI Sites over Population Density



Note: Figure 2 shows the location of TRI sites (blue dots) nationally (according to the National Institute of Health's Toxmap website, 2019) overlaid on a population density map by county. Darker blue areas are more population dense. TRI sites are disproportionately located in the most population dense areas of the United States. Source: National Institute of Health, U.S. National Library of Medicine, TOXMAP. https://toxmap.nlm.nih.gov/toxmap/app/

Figure 3: Event study of Particulate Matter after a TRI site Opening



Note: Figure 3 plots the coefficients from a regression of mean level of PM10 on leads and lags of a TRI site opening within a mile of the pollution monitor using pollution data from 1988 to 2012. T is the year the TRI site opens and all coefficients are normalized such that the coefficient in the year prior to opening (T-1) is zero. Dotted lines represent 0.95 confidence intervals for the coefficients. Standard errors are clustered at the pollution monitor level.

Online Appendix

Table A1: Long-Run Outcomes with Family Fixed Effects Limited to Children Conceived Within One Mile of a TRI site, Controlling for Maternal Marriage Status and Years of Childhood Poverty

	(1) Outcomes Index	(2) Log Wages	(3) On Public Assistance	(4) Years of Education	(5) Completed High School	(6) Attended College
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.797***	-0.374**	0.141*	-1.317***	-0.125**	-0.098
	(0.197)	(0.158)	(0.081)	(0.455)	(0.063)	(0.070)
Observations	1,179	953	1,261	1,114	1,206	1,189

Note: Columns 1-6 present the results for different long-run outcome variables. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for maternal marriage status at birth, total years of childhood poverty, birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table A2: Long-Run Outcomes with Family Fixed Effects Limited to First or Second Born Children Conceived Within One Mile of a TRI site

	(1) Outcomes Index	(2) Log Wages	(3) On Public Assistance	(4) Years of Education	(5) Completed High School	(6) Attended College
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.803***	-0.038	0.129	-2.059***	-0.159**	-0.123
	(0.232)	(0.241)	(0.101)	(0.597)	(0.077)	(0.090)
Observations	1,069	866	1,156	1,008	1,092	1,076

Note: Columns 1-7 present the results for different long-run outcome variables. Only first and second-born children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse of the number of times an individual is observed in the data. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table A3: Difference in Difference Results with Family Fixed Effects for Children Conceived Within One Mile of a TRI site, Compared to Siblings in Families Living 8 to 10 Miles Away

	(1) Outcomes Index	(2) Log Wages	(3) On Public Assistance	(4) Years of Education	(5) Completed High School	(6) Attended College
(Conceived when TRI Site is Open Compared to Conceived When TRI was Closed within 0-1 mile) – (Conceived when TRI Site is Open Compared to Conceived When TRI was Closed in 8-10 miles)	-0.604**	-0.154	0.143*	-1.256**	-0.136**	-0.027
	(0.243)	(0.175)	(0.084)	(0.576)	(0.064)	(0.083)
Observations	1,017	814	1,095	956	1,044	1,027

Note: Columns 1-6 present the results for different long-run outcome variables. Only children from families living consistently within one mile of a TRI site and not changing census tracts or zip codes between births are included in the analysis. Standard errors are adjusted for clustering at the site level. In addition to family fixed effects, regressions control for maternal marriage status at birth, total years of childhood poverty, birth month and year, birth order, birth spacing, age in the last survey wave, and gender. All regressions are weighted by the inverse probability of responding to the survey. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.