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

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Although pollution is widespread, there is little evidence about how it might harm children's long run outcomes. Using the detailed, geocoded longitudinal data, we compare children who were gestating before versus after a Toxic Release Inventory site opened or closed in their zip code. We find that children who were exposed prenatally to industrial pollution are more likely to be in poverty as adults, are less likely to attend college, have fewer years of completed education, and lower scores on a summary index of long run outcomes than unexposed children.

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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 educational and labor market outcomes. Toxic Release Inventory (TRI) sites are one type of industrial plants releasing hazardous chemicals throughout the United States. There are currently about 21,800 TRI sites operating across the United States and more than 221.5 million people had a TRI site operating in their zip code in 2016.[1] In addition, there are reasons to believe that the types of pollution emitted by TRI sites might be particularly detrimental to human health and development. For example, TRI sites release known neurotoxins, such as lead and mercury, into the air. While the six 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 (MATS). These regulations have been rolled back and are now being 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 2021), cause cancer, harm birth outcomes (Currie, Davis, Greenstone and Walker 2015), and harm the brain and reproductive system (Centers for Disease Control and Prevention 2009).[3] However,

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[1] We made this calculation based on linking zip code level census counts of the population to TRI data.
[2] The Supreme Court of the United States decided against the MATS rule in 2015 for lack of sufficient cost-benefit analysis and remanded the case to the U.S. Court of Appeals, which temporarily upheld the rule. In 2020, the EPA determined that it was not "appropriate and necessary" (A&N 2020 rule) to regulate hazardous air pollutants (HAPs, also known as airborne toxics) under the MATS rule and stopped some regulation of these airborne toxics. Litigation on the 2020 A&N rule is ongoing, which affects the legal basis of the MATS rule (Congressional Research Service 2020). On January 20, 2021, President Biden directed EPA to revisit the 2020 rule by August 2021, and the EPA has submitted a new proposed rule to regulate HAPs that is not yet in effect (EPA 2022).
[3] However, most of the evidence we have on the neurotoxic effects of these pollutants is from studies using animal models.

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.

We 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, we utilize two main identification strategies. In the first, we use a stacked difference in differences design in which we use either a TRI site opening or a TRI site closing to compare children in the same zip code who were conceived before versus after a TRI site opened or closed. In the second strategy, we 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. We compare siblings who do not move away from close proximity to a TRI site and estimate a 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 and using within-zip code and within-family comparisons, we are 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 live near a TRI site that could affect child outcomes.

The consequences of prenatal exposure to TRI pollution are stark. We find that children who were gestating near a TRI site that opened have 4.44 fewer years of education compared to other children in the same zip code, who were not prenatally exposed to the TRI pollution because they were gestating before the site opened. Children who are prenatally exposed to TRI pollution also are 64.2 percentage points more likely to be on a public assistance program as an adult than unexposed children in the same zip code. This represents a large increase of 160% in public assistance use above the mean. To alleviate concerns about the small sample size and multiple hypothesis testing, we also construct a summary index of long run outcomes that include education, wage, employment, and disability outcomes and find significant negative effects of prenatal exposure to TRI pollution, between -1.383 and -1.385 standard deviations.[4] In addition, children whose families do not move away from TRI sites are 85.4 percentage points less likely to attend college as an adult than others in the same zip code who were not prenatally exposed to TRI pollution.

This paper provides some of the first evidence that prenatal exposure to hazardous air pollutants (HAPs) can cause negative long-run human capital outcomes on wages, poverty status and educational attainment with important distributional consequences for fence-line communities of children who live within one mile of a TRI site in the United States. Most studies to date have focused on the negative effects of exposure to particulate pollution on birth outcomes[5] or contemporaneous test scores in primary or secondary school.[6] Although some research (Almond, Edlund, and Palme 2009; Bharadwaj et al. 2017; Black et al. 2019; Grönqvist, Nilsson and Robling 2020; Isen et al 2019; Persico, Figlio and Roth 2019; Sanders 2012) has focused on the negative effects of exposure to pollution during gestation or early life on later human capital outcomes, most of this work focuses on outcomes in primary or secondary school, rather than economic

[4] This index has a mean of zero and a standard deviation of one. See Section IV for more information on the construction of the long run outcomes index.

[5] 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).

[6] See, for example, Carneiro, Cole and Strobl (2021), Duque and Gilraine (2022), Ebenstein, Lavy, and Roth (2016), Gilraine and Zhang (2022), Heissel, Persico and Simon (2021), Marcotte (2017), Persico and Venator (2021), Pham and Roach (2023), and Sanders (2012).

outcomes in adulthood. Our paper is one of the few that can study long-run earnings and adult economic outcomes in the United States.

Two other studies estimate the effect of pollution on wages in the U.S. Isen et al. (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 are associated with a 0.7 percent decrease in the number of quarters worked and a one percent decrease in mean annual earnings. In a working paper, Voorheis (2017) also finds that pollution exposure in early life is associated with lower college attendance and wages. However, these papers use Census data at a much higher level of geography (the county level), and they are focused on the Clean Air Act amendments of 1970 and less policy relevant pollutants, such as Total Suspended Particulates. Using our detailed data, we also are able to more carefully study mechanisms through which HAPs pollution affects economic outcomes at a smaller level of geography than previous work, which can more precisely measure exposure. We also are able to study prenatal versus cumulative exposure, which is a strong contributions over previous work. Importantly, we use a time period after the full implementation of the Clean Air Act and the de-leading of gasoline to show that our estimates relevant to today's ambient air pollution.

Our findings are much larger than previous estimates of the effect of air pollution on wages, which highlights additional contributions of this paper. First, prenatal exposure to TRI pollution, which contains a mix of known neurotoxins like heavy metals, might be much worse than exposure to other types of air pollution, such as emissions from traffic or lead alone. Despite TRI sites being a commonly encountered source of pollution, this is the first paper to examine the effects of HAPs and TRI sites on outcomes in adulthood. It is worth noting that only 7.2 percent of TRI sites over our time period were releasing lead, and these sites did not provide identifying variation for this study, meaning that our findings are not purely driven by lead exposure. The average TRI site was releasing 26,195.21 pounds per year of 7.6 known toxic chemicals (per site) over this period, meaning that children were potentially being exposed to toxic stews of various chemical combinations. Second, we show that there are important distributional consequences for exposure to pollution wherein people living very close to TRI sites are much more strongly affected by the pollution, which could be missed by estimates that assume a county-level or regional treatment. Indeed, results using regional fixed effects are likely to be driven by people living very close to the sources of pollution, which has important implications for policy and where we locate these sites. Since disadvantaged families are more likely to live closer to TRI sites, exposure to pollution might push families without resources to avoid the pollution into poverty. Third, our analysis uses a stacked difference in differences design that addresses concerns about potential bias in two-way fixed effects models. We also show the results using family fixed effects, which remove observed and unobserved time invariant characteristics of families that might otherwise bias the findings, as well as a strategy that addresses bias caused by residential sorting by conditioning on the location of the first birth near a TRI site.

Fourth, given that TRI sites remain open for long periods of time, the potential length of exposure to TRI pollution for children in this sample is quite long (potentially 9 years). Thus, we show that these results reveal the effects of cumulative exposure as well as prenatal exposure. This analysis is also among the first to investigate how pollution might affect poverty and income in adulthood through educational, employment, crime, and health channels using very detailed data from surveys of the children of the National Longitudinal Survey of Youth 1979 (NLSY79) and their parents for families that live close to toxic sites. Finally, this paper contributes to a literature on how neighborhoods affect health, educational attainment, and intergenerational mobility, showing that even within a zip code, proximity to sources of pollution can cause inequality. We are further able to show that boys and low-income children are the most affected by pollution. The results are robust to a variety of specifications and suggest that pollution is a major channel through which inequality is reproduced.

II. Background

In 2017, Toxic Release Inventory (TRI) sites alone (which are federal or private industrial plants that release toxic pollution) 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). The Environmental Protection Agency (EPA) estimates that more than 59 million people (about 19 percent of the population) live within one mile of an operating TRI site (EPA 2014). 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. TRI sites are currently mandated to report the release of 787 potentially toxic chemicals (U.S. EPA 2023). 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.[7]

According to the "fetal origins" hypothesis, prenatal health conditions can have large impacts on health and brain development that reverberate into adulthood (Currie and Almond 2011). Such effects are persistent and occur through "fetal programming" that occurs in the womb through brain development or epigenetic mechanisms, which are just beginning to be explored. There is some evidence that environmental toxicants might interact with genetic susceptibilities to

[7] 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).

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. Randomized control trials of early-life epigenetic changes in rats show that these changes 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.[8]

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. 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

[8] 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).

blood-brain barrier, exposure to lead can lead to brain damage in the prefrontal cerebral cortex, hippocampus and cerebellum (Finkelstein et al., 1998).[9]

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.[10] Over our time period, 50% of TRI sites released volatile organic compounds (VOCs) and 39.2% of TRI sites released heavy metals. Another 23.73 percent of sites released other chemicals that are potentially hazardous, but less well known. 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), 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 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

[9] 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.

[10] 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.

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[11] 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.

Fewer papers, however, investigate the effects of pollution on later earnings. Black et al (2019) find effects on later earnings and educational attainment in Norwegian children exposed to radioactive fallout. Isen et al (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

[11] 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).

the number of quarters worked and a one percent decrease in mean annual earnings. In a working paper, Voorheis (2017) also finds that pollution exposure in early life is associated with modestly lower college attendance and wages. Grönqvist, Nilsson, and Robling (2019) show that children who were exposed to less lead through removing lead from gasoline in Sweden were more likely to graduate high school, were less likely to commit crimes, and had higher wages in adulthood.

However, there were several large environmental regulations that went into effect after the Clean Air Act Amendments of 1971. One of the big environmental regulations that emerged between 1971's Clean Air Act Amendment (Voorheis and Isen et al.'s setting) and my time period is the removal of lead from gasoline, paint, and a variety of other household items. This happened over time starting in 1973 and represents a large regulation of environmental toxics. In addition, there was a second Clear Air Act Amendment in 1977 that created a review and regulatory process for National Ambient Air Quality Standards (NAAQS), along with a scientific review committee. This amendment also added State Implementation Plan requirements for areas that had not attained the applicable NAAQS ("nonattainment areas") to reach Clean Air Act standards by 1977. In this paper, we are able to show that the type of pollution released by TRI sites has caused harm after these regulations went into effect, meaning that our results are more relevant to today's air quality standards.

Nevertheless, it is unclear what mechanisms might underly the relationship between pollution and long-run human capital outcomes and whether certain types of pollution, like HAPs, might have bigger impacts on wages. In addition, this is the first paper to investigate the spatial, racial and socioeconomic distributional consequences of prenatal pollution exposure on long-run outcomes, as well investigating whether cumulative exposure or exposure at different ages matters. Most studies to date are unable to account for time-invariant characteristics of families and neighborhoods that could affect child outcomes. Finally, this paper examines an understudied, yet commonly encountered type of pollution (TRI pollution) that creates a situation in which communities are potentially exposed for years. 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

We employ two different identification strategies to estimate the effects of prenatal exposure to TRI pollution on long run outcomes. First, we evaluate the effects of in-utero exposure to environmental toxicants on children by comparing all children in the same zip code who gestated before versus after a TRI site opening (or closing) using a stacked difference in differences design. While a variety of factors are related to living near a TRI site, as shown in Table 1, the *timing* of openings and closings is plausibly random with respect to conceptions, as shown in Tables A1 and C8 even if the openings and closings are not.

Because this design does not allow for the treatment variable to turn on and off, we estimate the effects of openings and closings separately. We use TRI site openings as our primary identification strategy because there is more variation, but we show a parallel set of results for closings in Appendix B.[12] 693 TRI sites opened and 497 sites closed between 1970 and 1998, the latest birth year for which we could observe adult outcomes. We take any zip codes that experience a TRI site opening as a treated zip code, and zip codes that experience an opening in the future or who are more than 8-10 miles away from a TRI site as control zip codes. We create separate clean data sets for each opening and stack them together so that they align in event time.

Following Cegniz et al (2019), our basic stacked difference in differences estimation is given by:

[12] For the sake of clarity, we describe the situation for TRI site openings, but closings follow the same logic.

(1) $Y_{izt} = \sum_{\tau=-8}^{11} \sum_{k} \alpha_{\tau k} D_{izt}^{\tau k} + X_{it} + \eta_{zj} + \theta_{tj} + \epsilon_{izt}$

Where Y_{izt} is some outcome of a child *i* born in zip code *z* at time *t*. We 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,[13] years of education, the likelihood of graduating high school, college attendance, as well as a summary index of adult outcomes. $\mathrm{D}_{\mathrm{izt}}^{\tau\mathrm{k}}$ is a dummy variable for whether a child was conceived while a TRI site opened τ years from the date *t*. We limit the sample to areas where the TRI site was open for at least 10 years so we can estimate the effects over this period. η_{zj} is a zip code by stack fixed effect, where each stack *k* is determined by zip code by TRI opening year. θ_{tj} is a birth year by stack fixed effect, and X_{it} is a vector of child-specific control variables (i.e., gender, race, birth order fixed effects, birth month fixed effects, birth spacing, age in the last survey wave in 2016, maternal marriage status at the time of birth, maternal drinking during pregnancy, poverty status in the birth year, total years of childhood poverty, maternal education, preschool attendance, and whether the family moved after the birth[14]). The models that analyze economic outcomes (such as wages and 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. While we include all children in a zip code with an opening, we weight the regressions by the inverse of the distance to the nearest TRI site to account for the fact that children closer to TRI pollution will be more affected by it. ε_{ijt} is an error term. Standard errors

[13] We define adulthood in this context as age 23 or older. We 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). We do not include veteran's benefits, etc.
[14] The results are nearly identical if we do not control for years of childhood poverty.

are clustered at the TRI site level, which will account for the repeated appearance of the same zip codes since zip codes are fully nested within openings.[15]

As shown in Panel A of Figure 1, Particulate Matter 2.5 (PM25) is much more concentrated with one mile of a TRI site.[16] Heavy toxic compounds, such as lead, and PM10 also deposit in larger quantities more locally after being emitted into the air (Miranda et al 2011; Zahran et al 2023). Panel B is an event study showing that there is a statistically significant increase in PM2.5 of about 11% of a standard deviation following a TRI site opening within 1 mile of a TRI site.[17] Most TRI sites (72% in 2018) primarily emit air pollution and usually release a variety of pollutants such as PM2.5, PM10, lead, and ozone.

We also employ two additional identification strategies that both use a family fixed effects design. Our first comparison is a reduced form analysis where we account for potentially endogenous mobility by conditioning on the location of the first birth near a TRI site (and the open/close dates for that site) for all siblings in the same family born earlier or later, regardless of whether the family moved. In this specification, we are not using an instrumental variables design, but rather a reduced form in the spirit of intent-to-treat designs in which initial random assignment is used in place of observed treatment status. In other words, we 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 the first-born sibling was

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[15] The results are also robust to clustering at the zip code level.

[16] This distance was calculated based on the population-weighted zip code centroid of a child's birth. See Section IV for more details.

[17] A similar result was obtained by Persico and Venator (2021) for the distance traveled by PM2.5 and PM2.5 having increased after a TRI site opening. Furthermore, there is evidence from environmental modeling that airborne toxics, such as heavy metals, from TRI sites are concentrated at closer distances to a facility (Chakraborty, Maantay and Brender 2011; Dolinoy and Miranda 2004).

conceived within 1 mile of an operating TRI site.[18] Second, we compare siblings whose family does not move between births (though they might have moved before or afterwards) 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.

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, which motivates our use of family fixed effects. By using family fixed effects, we are controlling for both time invariant characteristics of families that are both observed and unobserved, as well as some selection into neighborhoods. Many of the inputs to human capital development during childhood, such as neighborhoods, parenting strategies, family income, etc. will be the same for both siblings. Without accounting for such things, estimates might be biased.

Thus, our identifying assumption is that the only thing that changed between conceptions of siblings was that the local TRI site closed or opened (regardless of where later children were born). Because the timing of TRI site openings and closings is plausibly unrelated to the timing of conception, comparing siblings near a TRI site should yield an unbiased estimate of the effect of exposure to TRI pollution during gestation. Later in the paper we describe a variety of the tests and specification checks that we undertake to determine the degree to which our results are internally valid.

Our basic family fixed effects estimation for both specifications is given by:

$$(2) \quad Y_{ijt} = \beta_1 ClosestSiteWithinMileisOpen_{ijt} + X_{ijt} + \theta_j + \gamma_t + \varepsilon_{ijt}$$

[18] We estimated the timing of conception by subtracting the weeks of gestation from the birth date. We also estimated the timing of exposure on the basis of the timing of the opening and closing of TRI sites.

Where Y_{ijt} is some outcome of a child i born to family j at time t. We 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,[19] 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, adult marital status, age in the last survey wave in 2016, maternal marriage status at the time of birth, maternal drinking during pregnancy, and total years of childhood poverty). The models that analyze economic outcomes (such as wages and 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, we weight the regressions by the inverse of the number of times an individual is observed in the adult survey data. ε_{ijt} is an error term. Standard errors are clustered at the TRI site level.[20]

Since children who live near TRI sites are more disadvantaged, as shown in Table 1, one might be concerned that other neighborhood factors might contribute to disparities in outcomes. Our estimates also could be biased if there are unobserved factors affecting the outcomes of

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[19] We define adulthood in this context as age 23 or older. We 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). We do not include veteran's benefits, etc.
[20] The results are also robust to clustering at the zip code level.

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 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, we also compare children in the same family in which we use the location of the first birth in the family near a TRI site (and the first TRI site status and location) for all other siblings born later, regardless of whether the family moved. This specification allows us to address residential sorting and avoidance behavior by proxying the location of the first birth and treatment status for all later-born siblings. Thus, one would expect these estimates to be smaller since some untreated siblings might count as treated and some treated siblings might count as untreated if families moved. In an additional specification, we compare children in the same family who do not move between at least 2 births (though they might have moved earlier or later). We 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. While in our preferred family fixed effects specification, first-born children are all likely to be exposed to TRI pollution during gestation, in the non-movers specification, there is more heterogeneity in which sibling is exposed prenatally. We show that our 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. There could also be negative spillovers within a family in which one siblings was exposed, which would bias the results towards zero. Thus, we use a stacked difference in differences design at the zip code level as our main specification throughout the paper, since this also increases our sample size.

Our results might also be biased towards zero if there exists measurement error in the recorded timing of openings and closings. We 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. We check this by using the raw TRI data in Section VC.

IV. Data Description

In this study, we 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 we focus on include (1) labor market and economic status outcomes (measured biannually and expressed in 2000 dollars) – wages, family income (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[21] and the likelihood of having a cognitive disability.[22] Wages, defined by annual earnings/annual work hours, is our main labor market outcome. We compute wages for only those who have positive earnings in a given year, and valid data exists for 79 percent of the sample.[23] The average wage (in 2000 dollars) at age 30 for the whole sample is $15.20.[24]

To reduce measurement error and address concerns about multiple inference, we construct a summary index of outcome measures (Kling, Liebman, and Katz 2007; Deming 2009). We 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., we flip the sign for being on public assistance or having disabilities), and take the simple average across those outcomes. We 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. While our primary analytic sample is small, we are identifying off of 3,613 children in our preferred stacked difference in

[21] Having any disability is defined as reporting having a cognitive disability, epilepsy, a nervous disorder, a heart problem, cancer, or being handicapped.
[22] Having a cognitive disability is defined as having a learning disability, ADHD/hyperactive, intellectual disability or a speech impairment.
[23] We drop a few implausibly low wages that are lower than $2.75 per hour, as well as wages for those who report being in college in the year of the wage observation.
[24] As shown in Table 1, the average age of the most recently observed wage of the respondent in our sample is 29.

differences specification using TRI openings. Our sample using TRI closings also contains 3,189 children.

We 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,[25] we 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 we were able to match TRI sites based on business names and address information. We 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.[26] As shown in Figure A1, TRI sites are mostly located in the most densely populated areas of the United States.

Using geocoded census-tract and zip-code data from the NLSY79 and latitudinal and longitudinal coordinates for TRI sites, we calculate the closest distance between the population-weighted census tract or zip code centroid and the nearest TRI sites in the year a child was born. The sample in this study includes every child born in the CNLSY data, dropping zip codes with more than one TRI site. We also match these data to additional census tract and zip-code level census data from the 1980, 1990, 2000 and 2010 censuses.

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[25] 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).

[26] 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 we assigned its opening date as 1970. The results are also robust to the assignment of different opening dates.

Table 1 presents the characteristics of children of NLSY79 respondents overall in Column 1, within one mile of a TRI site in Column 2, within one mile of an open TRI site in Column 3, and our primary sample for TRI site openings is in Column 4. Column 5 shows characteristics of children who experience a TRI site closing, and Column 6 show characteristics of siblings living within 1 mile of a TRI site that opened or closed. 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. Children in our main sample (Column 4) are very similar to other children living within one mile of a TRI site. On average, children who are exposed to TRI pollution would be exposed for 9 years if they never move away from the TRI site. However, 19.9% of families move between births in the sample. Column 5 shows that children exposed to TRI site closings are very similar to children exposed to TRI site openings (Column 4). Column 6 shows the characteristics of children in the sample of children we use for our family fixed effects estimates. Table A1 (and C8) shows that indeed, there is no correlation between the conception year of children in the sample and the year of TRI openings or closings.

V. Long-run Outcomes of TRI Exposure During Gestation

A. Main Results

Table 2 presents our main results for our preferred specification that uses a stacked difference in differences design with zip code fixed effects for several long-run outcomes: the index of outcomes, the likelihood of being on public assistance as an adult, log of wages, log of individual income, years of education, the likelihood of high school completion, likelihood of attending college, and having a cognitive disability. Panel A restricts the sample to TRI site openings, and Panel B shows the same results when restricting to TRI site closings. Each column of Table 2 presents results from our preferred stacked difference in differences specification that compares children in the same zip code with and without TRI pollution exposure during gestation, controlling for all variables outlined in Section III.[27]

Beginning with Panel A of Table 2, we find that children prenatally exposed to TRI pollution have 1.38 standard deviations lower outcomes on the outcomes index than other children born before a TRI site opening in the same zip code. They are also 64.2 percentage points more likely to be on public assistance in adulthood and have 4.437 fewer years of education. Importantly, they are 85.4 percentage points less likely to attend college.

In addition, Panel A of Table A2 shows the results when using Callaway and Sant'Anna's (2019) estimator, which accounts for potential underlying heterogeneity. Panel C of Table 5 shows the results when we only use the data from the TRI and do not impute start and end dates from the tax records. Panel B of Table A2 shows these results controlling only for family, birth month and birth year fixed effects. The samples and pattern of results are very similar for all three specifications, except that the Callaway and Sant'Anna estimator shows larger negative results for wages rather than adult poverty.

The results for TRI closings in Panel B of Table 2 are very similar to the results for openings. One might expect TRI site closings to produce larger effects than openings since in the case of closings, only children born before the closure are exposed to TRI pollution, while in the case of openings, all children in the zip code are exposed to the pollution, but at different ages.

[27] The regressions are weighed by the inverse of the distance to a TRI site.

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. In addition, some TRI chemicals might linger in a mother's body, exposing later-born children even if the site is no longer operating.

Table A3, B6 and C11 present some additional long run outcomes that could constitute other mechanisms through which TRI pollution affects long run outcomes. We find no statistically significant effects for being employed or on unemployment, being convicted, on probation or in prison, being married or low birth weight. However, we find that children who were prenatally exposed to TRI pollution have lower Peabody Individual Achievement Test (PIAT) math and reading scores and score higher on the Behavioral Problems Index. This shows that children are more likely to exhibit higher levels of behavioral problems in childhood, though this might not translate into statistically significant criminal justice outcomes in adulthood due to sample size and the rarity of the outcome.

We also conduct a mediation analysis in Table A4 (and B7) and find that the results are not explained by having a cognitive disability, employment or birth weight. Instead, about 79% of the effect of prenatal exposure to pollution on the outcomes index is explained by fewer years of educational attainment. However, the mediation analysis when controlling for family fixed effects (Table C12) does suggest that cognitive disability, employment and low birth weight play a mediating role in the outcomes as well, though none of these fully explain the pattern of results.

Figure 2 presents our main results for our stacked event study design with zip code fixed effects for the same outcomes, showing very similar results. The figures similarly show that children who were prenatally exposed to TRI site pollution after a site opening have lower scores on the outcomes index, have fewer years of education in adulthood, are less likely to graduate high school or attend college, and have a higher incidence of cognitive disability than children born before a TRI site opening in the same zip code. Importantly, the results last for at least 10 years after a TRI site opens. A parallel set of results for TRI site closings is presented in Appendix B (Figure B1).

However, the results for being on public assistance are notably weaker in the event study estimates. While the stacked difference in difference estimates are not statistically significant at conventional levels for wages or income in Table 2, the log of wages in Panel G shows some suggestive wage growth after a TRI site opening, consistent with a TRI site providing economic opportunities. Because TRI pollution could have differential impacts on wages at different parts of the wage distribution, we also estimate a simultaneous quantile regression of the effects of gestational exposure to TRI pollution on wages, controlling for zip code fixed effects and all other controls. Panel A of Figure 3 shows that the largest effects on wages are seen in the 60th through 80th percentile of the wage distribution, relative to the 10th through 50th percentiles. This implies that people in the higher quantiles of income are more negatively affected by TRI pollution.

The effect of TRI pollution on wages might not be significant, but the effect on poverty might be, if there are heterogeneous effects by distance from a TRI site or increases for some groups with decreases for other groups. Indeed, Panel B of Figure 3 and Figure C1 show that the effects are strongest within a mile of a TRI site. In addition, Figure A2 plots the results of a stacked event study on long run outcomes for non-moving families living within one mile of a TRI site. The event studies show that the effect of prenatal exposure to TRI pollution on adult poverty is larger and the effects on income and wages are more negative when restricting to areas closer to TRI sites. We discuss this further in the following sections.

B. Family Fixed Effects Results

Because pollution exposure is not randomly distributed, it is important to account for time invariant characteristics of families and neighborhoods that could affect child outcomes in adulthood. This motivates our use of family fixed effects in Table 3. Table 3 presents individual estimates for the same set of long run outcomes for siblings within one mile of a TRI site in which one sibling was exposed and the other(s) was not because of a TRI site opening or closing. Panel A presents the results of our preferred specification in which we 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. It is important to note that the models that analyze 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).

Being exposed to air pollution prenatally is associated with large negative effects on long-run outcomes, though the magnitude of the results is substantially reduced when using family fixed effects. This might be because family fixed effects absorbs some omitted variables or because intra-family spillovers reduce the magnitude of the results. Children who are exposed to TRI sites during gestation also have 40.7% of a standard deviation worse outcomes on the long run outcomes index, 23.2% lower wages ($p<0.06$) and 0.760 fewer years of education than their unexposed siblings. In addition, they are 12.7 percentage points more likely to be on public assistance in adulthood compared to their unexposed sibling ($p<0.06$). However, we do not find a statistically significant effect on high school completion, college attendance, income, or disability, though the pattern of results suggests negative effects. While not all coefficients are statistically significant (likely due to small sample size), we estimate that the likelihood of all coefficients in Panel A following this pattern of negative results by random chance (from a joint F test) is 0.002. Panel A of Table C9 shows these results controlling only for family, birth month and birth year fixed effects. The pattern of results is very similar. The negative effects on the outcomes index in both specifications is predominantly driven by decreased educational attainment, as shown in Panel D of Table C9.[28]

The estimates in Panel B of Table 3 present the results from the specification that compares non-moving siblings. In Panel B, we find that being prenatally exposed to TRI pollution have 57.2% of a standard deviation worse outcomes on the outcomes index, 29.7% lower wages and are 18.8 percentage points more likely to be on public assistance as an adult than their siblings, which represents a 47.7 percent increase above the mean. They also complete 1.266 fewer years of education and are 12.9 percentage points less likely to complete high school than their siblings who were not prenatally exposed to TRI pollution. We find that children exposed to TRI pollution prenatally are also 7.32 percentage points more likely to have any disability and 9.62 percentage points more likely to have a cognitive disability than their siblings.[29] This represents a 140% increase in disability rates overall and a massive 349.8% increase in cognitive disabilities. The point estimates also imply that cognitive disabilities drive the results on disability.

While a 30% decrease in wages might sound large, one would get similar estimates to the rest of the literature on pollution and wages if the results are driven by children within 1 mile of a TRI site but being diluted by using large units of geography. As a rough calculation, if the average county population is 107,086 in 2019 and there are 11 births per 1000 people (NCHS 2021) and approximately 19% of the population lives within 1 mile of a TRI site, that means that 224 out of

[28] As shown in Panel D of Table C9, dropping the variables for educational attainment from the outcomes index produces an estimate that is much smaller and not statistically significant at conventional levels. This suggests that the outcomes index is mostly capturing years of education.
[29] Because there could be differential slippage between these categories over time, we examine cognitive disabilities separately and together.

1,178 births per county every year are within 1 mile of a TRI site. If those 224 births have on average a 30% decrease in wages, but the other births are largely unaffected, a weighted average produces the estimate of 5.7% lower wages on average for the county. This is only slightly larger than Grönqvist, Nilsson, and Robling (2019)'s estimate of the effects of airborne lead on wages (4%), though they use neighborhoods rather than counties.[30] Nevertheless, these estimates are still larger than others obtained in the literature, likely because this type of pollution does affect people farther away than one mile and for a long time.

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. In addition, exposure lengths to these chemicals are likely to be longer than those in previous studies if families do not move away from these sites.

C. Heterogeneity of Estimated Effects

Because pollution might affect groups differently, Table 4 presents estimates of the effects of exposure to TRI pollution by gender, race and socioeconomic status. Panel A presents the results for boys, while Panel B presents the results for girls. Although most results are not statistically different from each other, the pattern of results suggests that exposure to TRI pollution has negative effects for girls and boys. The outcomes index is -1.358 standard deviations lower for boys

[30] Panel C of Table A2 uses a stacked difference in differences approach at the county level to estimate the effect of TRI site openings on child outcomes. While none of the point estimates are statistically significant at conventional levels, the pattern of negative results holds.

(relative to other children in the same zip code), compared with -1.41 lower for girls, which is significant at the $p<0.05$ level. Both girls and boys who were prenatally exposed to TRI pollution are more likely to be on public assistance in adulthood and have fewer years of completed education (4.2 fewer years of education for girls, compared with 4.6 fewer years for boys), relative to other children in the same zip code.

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 somewhat larger in magnitude for low-income children than for higher income children. Low-income children who suffered prenatal pollution exposure have 1.64 standard deviations lower outcomes on the outcomes index than their zip code peers, compared to 1.33 standard deviations lower outcomes for higher income children, and these estimates are different from each other at the $p<0.1$ level. Low-income children with prenatal exposure to TRI pollution are much more likely to be on public assistance in adulthood, relative to higher income children. Low-income children have 4.67 fewer years of education and are 88.1 percentage points less likely to attend college than unexposed children in the same neighborhood. In comparison, wealthier children have 4.39 fewer years of education and are 84.9 percentage points less likely to attend college than unexposed children. TRI pollution might be worse for lower income families because low-income children live in closer proximity to the TRI pollution than wealthier children and have less ability to practice avoidance behaviors or compensate for early pollution exposure. However, the pattern of findings also suggest that pollution could harm 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.[31] Overall, the pattern of result suggests that the effects of exposure to industrial pollution are worse for Black and Hispanic children ($p<0.05$) (compared to unexposed neighborhood peers) than White children. This might be the case because Black and Hispanic children are more likely to live nearer to TRI sites than White children. Black and Hispanic children have worse outcomes on the outcomes index, are more likely to be on public assistance, and are less likely to attend college, relative to their White peers who were also exposed to TRI pollution (based on the p values of the comparison of estimates).

Our identification strategy relies on the theory that residences closer to TRI sites will have greater exposure to pollutants. However, the air quality monitoring data over this time period is somewhat sparse. In addition, there could be some error due to using population-weighted zip code centroids. Thus, Panel B of Figure 3 (and Panel B of Figure C1) presents the results disaggregated by distance from the TRI site, in which we interact an indicator for the site operating with distance bins (for example, site is open x <1 mile, site is open x 1-2 miles, etc.), with the children who are farther than 8 miles from a TRI site as the control group. As expected, the strongest effects are on children who are closest to the TRI site, with children living less than 1 mile from the TRI site having 40% of a standard deviation worse outcomes relative to unexposed children in the same zip code.[32] However, the effects on long run outcomes appear to fade out rapidly over distance.

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

[32] We were unfortunately unable to run this specification using a stacked difference in differences design since this design uses the variation within zip codes. The estimates are somewhat smaller when just using zip code fixed effects.

In addition, we investigate whether the results might be explained by parental exposure to TRI pollution through their jobs or years of exposure to TRI pollution beyond gestation. While we do not have access to information on the company at which parents were employed, we do have information on what type of job a parent had. Panel A of Table 5 shows our main specification for being conceived while a TRI site was operating (compared to other children in the same neighborhood), as well as an interaction term for being conceived while a TRI site was operating interacted with a binary variable for whether the parent's job was possible related to TRI sites (i.e., whether they worked in mining, manufacturing, utilities, wholesale, or as a machine operator) while a child was gestating. The interaction term is not statistically significant at conventional levels across outcomes, but there is suggestive evidence that children whose parents work in a TRI-related industry might have better outcomes than those whose parents do not work in a TRI-related industry based on the p value of the difference between the point estimates. This might be because these industries pay well, so these families are less likely to be in poverty.

To investigate whether postnatal exposure to TRI pollution matters, in Panel C of Figure 3, we estimate the effect of cumulative years of exposure. We find that the largest effects seem to be driven by children who were exposed to TRI pollution for 5 or 6 years. In addition, in Panel D of Figure 3, we test exposure to TRI sites at different ages. The findings suggest that prenatal exposure is most important, with exposure after the gestational period having small effects. We take this as suggestive evidence that prenatal and early life exposure is potentially worse than the total number of years exposed. However, we cannot rule out that the results are driven through cumulative exposure, as well as prenatal exposure, given the long time periods children tend to live around these sites.

Another important question for policy is what types of industries and pollution drive these effects. While there is not enough variation to estimate the effects of lead-emitting industries alone, in Panel A of Tables A5 and B8 we estimate an exploratory analysis in which we regress the long run outcomes index on prenatal exposure by different types of TRI industries. We find that power plants have the largest negative effects on outcomes. However, all industry types are associated with negative effects on children's long run outcomes indexes. In Panel B of Tables A5 and B8, we limit our analysis to only TRI sites that do not release heavy metals, and the results are quite similar to our main specification, suggesting that these effects are not due to lead poisoning. In Panel C, we show that a child experiencing above median amounts of TRI pollution in their birth year leads to a 708% of a standard deviation lower outcomes index, compared to unexposed children in the same neighborhood ($p<0.05$). This is nearly twice the size of the estimate in Column 5 for children experiencing below median amounts of pollution in their birth year. Thus, the amounts of pollution emitted are also a likely factor in how much a child is harmed by pollution.

Another concern is whether lead regulation changes, such as the de-leading of gasoline in the 1970s or improving environmental policy through the formation of the EPA might have played a role in the magnitude of these results. Panel B of Table 5 shows the effects of prenatal exposure to TRI sites using only data from 1980 to 1998 – a time period in which there had already been several regulations to remove lead from gasoline, meaning that there was far less ambient lead in the air. In Panel B of Table A5, we also limit our analysis to only TRI sites that do not release heavy metals (including lead). The results in both analyses are quite similar to our main specification, suggesting that these effects are not due to lead poisoning and are more relevant to today's ambient air pollution, which contains less lead than in the past. This suggests that TRI pollution is still likely to have negative effects on children born more recently.

D. Additional Threats to Internal Validity

One potential 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 children in the same zip code so that children born when TRI sites were operating experienced married parents or parents with higher education and more resources than children born during a TRI site operating because of the economic development a TRI site opening might cause. While we do not have data on all factors that might have changed between families, we test for this directly in Panel A of Table 6 by comparing years of maternal and paternal education and whether the mother was married, reported at birth, between children who were exposed to TRI pollution, relative to children in the same zip code who were conceived before it opened. We also compare total years of childhood poverty, the month prenatal care was first obtained, whether the mother smoked or drank during pregnancy, whether a child ever attended preschool, and whether the family moved between children who were exposed to the TRI pollution, compared with their unexposed peers. Table B3 presents a parallel set of results of TRI closings. The results, presented in Table 6, are not statistically significant, with the exception of maternal marital status, prenatal care, and total years of childhood poverty, which we control for our in our main specification. However, TRI sites opening are associated with a small decrease in families moving between births, possibly because of increased economic opportunities in the neighborhood. In addition, having an increased rate of maternal marriage and more prenatal care should improve outcomes, but the outcomes for children conceived when a TRI site was open are worse than the outcomes of children conceived when a TRI site was closed in the same neighborhood.

One might also be concerned that the opening 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 opening causes more educated and affluent people to enter a neighborhood, later born children might do better in school than earlier born children because the composition of children in neighborhoods changed, leading to positive peer effects. While we do not have data on the schools children born to NLSY recipients attended, we can compare neighborhood characteristics between births. Using data from the 1980, 1990 and 2000 Censuses, we compare median home values, median income, percent of dwellings that are rented, the percent Black and percent Hispanic[33] at the zip code or census tract level for children prenatally exposed to TRI pollution, relative to other children who were not exposed in the same neighborhood. The results, presented in Panel B of Table 6, show that children experienced roughly similar neighborhoods before versus after an opening (or closing in Table B3). However, children conceived when a TRI site was operating experienced an increase in median household income of $332 in the zip code, which should improve outcomes. Nevertheless, on average there are few economically meaningful differences in neighborhood characteristics between the neighborhoods children experienced.[34] Similarly, 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.

One might also be concerned that a few very polluted TRI sites are driving the results. Thus, Table 7 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 80th percentile nationally. In other words, we 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

[33] We linearly interpolate these values for missing years of data.
[34] While Currie et al (2015) find that TRI sites lower housing values by 11%, they examine a much longer time period in 5 states. Since the average gap between siblings is roughly 3 years in our data, not finding much change in housing prices in that time might make sense in this context.

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.[35] The results in both Panels A and B are very similar to those in Table 2. This suggests that it is not negative selection into certain neighborhoods or especially bad TRI polluters that drive the results.

One might be concerned that even though we control for birth spacing, birth order and birth month and year, that the results using sibling fixed effects might be driven by children who are very different in birth order. Thus, in Panel C of Table C5 we 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. To test this further, we estimate a specification in Table C15 that is limited to siblings gestating within one mile of a TRI site that was not operating. Birth order does not have statistically significant effects on the outcomes index or years of education. In addition, we also estimate the effects of prenatal exposure to TRI sites using a difference in difference strategy in which we 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.[36] The results, presented in Panel B of Table C10, are quite similar to the main results in Table 2, suggesting that time trends over this time period and birth order do not substantially affect the results. We also show in Table A1 (and C8) that there is no correlation between the timing of TRI openings or closings and the year of conception of the children in our sample, suggesting that conception is random in relation to TRI openings and closings.

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[35] Bad-sounding names were names that included the words "industry", "concrete", "metal", "chemical", "pharmaceutical", "plastic", "manufacturing" or "power plant." we also flagged any names that sounded like something one would avoid living near, like oil refineries, landfills, recyclers or industrial names.

[36] This specification has the advantage of estimating birth order effects more cleanly, as well as accounting for time trends.

One might also worry that there could be bias from who responds more often in the data. Table A6 shows the correlation between the number of times a child is observed in the data and child characteristics. Appearing an additional time in our data is not correlated with a variety of demographic characteristics.

In Table C13, we present the results of an exploratory analysis in which we estimate the effects of pollution on children for TRI sites that report emitting pollution through stacks, compared with TRI sites that have fugitive emissions, which are releases that do not undergo processing before release. 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. Both specifications maintain the family fixed effects model. The results presented in Panels A and B of Table C13 show that the pattern for stack releases and fugitive releases is quite similar overall. However, the effects on the outcomes index are somewhat larger for fugitive releases, but the effect on public assistance is larger for stack releases.[37]

VI. Conclusion

This is the first study to examine the long-run effects of living near industrial pollution on wages, income, adult poverty, years of education, high school completion, and the development of cognitive and other disabilities. Children prenatally exposed to TRI pollution experience 4.44 fewer years of education, are 64 percentage points more likely to be in poverty as adults and have

[37] 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.

138 percent of a standard deviation worse outcomes on a summary index than unexposed children in the same zip code. When comparing children in the same family, we find that children also have 29.7% lower wages, a 18.8 percentage point increase in the likelihood of being on public assistance as an adult, 1.266 fewer years of education, and a 12.9 percentage point increase in dropping out of high school, relative to their siblings who were not exposed during gestation. They also have a 7.32 percentage point increase in disability rates overall, as well as a 9.62 percentage point increase in cognitive disabilities. Overall, the pattern of results suggests 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 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, we 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 benefits cost of $22,103.30 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 $2.1 billion per birth cohort per year from TRI pollution.[38]

[38] This calculation uses the most conservative estimate in column 4 of Table 3 (0.127) to estimate the cost of the additional fraction of people who would need public assistance.

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.

We 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, we 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, our 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-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 et al, 2013).[39]

Unfortunately, our 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. This is the first paper to examine whether exposure to especially hazardous air 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 proximity to 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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Table 1: Characteristics of Children in the Samples

	(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	(4) Characteristics of Children in the Main sample for TRI Site Openings (Stacked DID)	(5) Characteristics of Children in the Main sample for TRI Site Closings (Stacked DID)	(6) Characteristics of Children Within 1 Mile of a TRI Site (Sibling FE sample)
Maternal Education at Birth	12.87	12.38	12.37	12.29	12.33	12.46
Paternal Education at Birth	12.64	12.47	12.51	12.23	12.21	12.55
Mother was in Poverty in Birth Year	0.168	0.254	0.269	0.232	0.233	0.263
Years of Education in Adulthood	13.69	13.28	13.49	13.65	13.79	13.31
Percent Black	0.157	0.214	0.212	0.311	0.289	0.215
Percent Hispanic	0.080	0.167	0.159	0.147	0.153	0.148
Maternal Marriage Status	0.744	0.606	0.610	0.496	0.485	0.592
Attended Preschool	0.662	0.622	0.613	0.517	0.519	0.620
Age of Oldest Observed Wage	28.74	26.38	26.58	29.62	29.67	29.01
Years Exposed to TRI Pollution if Respondent Does not Move Away	1.564	5.067	10.60	9.032	9.979	6.554
Observations	11,521	2,260	1,082	3,613	3,189	1,704

Notes: This table depicts the mean 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. Column 4 shows characteristics of children in the main sample in which we use a stacked difference in differences approach and identify off of TRI site openings. Column 5 shows the characteristics of moving families in the main sample. Column 6 shows characteristics of non-moving families.

Table 2: Individual Long-Run Outcomes from Gestational Exposure to a TRI Site Opening or Closing using Stacked Difference in Differences

	(1) Outcomes Index	(2) Log Wages	(3) Log of Individual Income	(4) On Public Assistance	(5) Years of Education	(6) Completed High School	(7) Attended College	(8) Has a Disability	(9) Has a Cognitive Disability
	Panel A: Restricted to TRI Site Openings								
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.383**	0.117	0.461	0.642**	-4.437***	-0.286	-0.854***	-0.0389	0.00216
	(0.537)	(0.269)	(0.392)	(0.258)	(0.821)	(0.484)	(0.274)	(0.131)	(0.115)
Observations	3613	2538	2788	3427	3126	3432	3398	3613	3613
Mean of outcome	0.0808	2.368	9.643	0.411	13.31	0.842	0.632	0.0617	0.0316
	Panel B: Restricted to TRI Site Closings								
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.385***	-0.0470	0.0890	0.548**	-4.353***	-0.328	-0.833***	-0.00178	0.0234
	(0.515)	(0.286)	(0.399)	(0.250)	(0.818)	(0.481)	(0.259)	(0.134)	(0.117)
Observations	3189	2250	2467	3027	2752	3022	2990	3189	3189
Mean of outcome	0.101	2.375	9.651	0.401	13.37	0.850	0.639	0.0599	0.0320

Notes: Columns 1-9 present the results for different long-run outcome variables. The estimates in Panel A are from our preferred specification that uses a stacked difference in differences design at the zip code level, restricted to TRI site openings. In Panel B, we show our stacked difference in differences estimates at the zip code level, restricted to TRI site closings. Standard errors are adjusted for clustering at the site level. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 3: Individual Long-Run Outcomes with Family Fixed Effects for Children Conceived Within One Mile of a TRI Site

	(1) Outcomes Index	(2) Log Wages	(3) Log of Individual Income	(4) On Public Assistance	(5) Years of Education	(6) Completed High School	(7) Attended College	(8) Has a Disability	(9) Has a Cognitive Disability
	Panel A: Adjusting for Residential Sorting								
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.407***	-0.232*	-0.0979	0.127*	-0.760**	-0.0646	-0.0632	0.0462	0.0613
	(0.130)	(0.121)	(0.162)	(0.0658)	(0.370)	(0.0546)	(0.0674)	(0.0334)	(0.0386)
Observations	1704	1141	1258	1562	1383	1527	1504	1704	1704
Mean of outcome	0.0870	2.411	9.665	0.399	13.30	0.835	0.616	0.0552	0.0282
	Panel B: Restricted to Non-Moving Families								
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.572***	-0.297**	-0.0969	0.188**	-1.266***	-0.129**	-0.0760	0.0732*	0.0962**
	(0.161)	(0.132)	(0.258)	(0.0755)	(0.434)	(0.0584)	(0.0634)	(0.0403)	(0.0475)
Observations	1,399	958	1045	1,295	1,138	1,235	1,217	1,530	1,530
Mean of outcome	0.123	2.400	9.694	0.394	13.40	0.849	0.629	0.0523	0.0275

Notes: Columns 1-9 present the results for different long-run outcome variables. The estimates in Panel A are from our preferred specification in which the location of the first birth near a TRI site is used for all other children in the same family. In Panel B, 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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: Long-Run Outcomes by Gender, Race and Poverty Status at Birth

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Boys				
Conceived when TRI Site is	-1.358**	0.565*	-4.617***	-0.311	-0.841***
Open (Compared to Closed)	(0.551)	(0.302)	(0.730)	(0.464)	(0.277)
	Panel B: Girls				
Conceived when TRI Site is	-1.410**	0.723**	-4.239***	-0.258	-0.869***
Open (Compared to Closed)	(0.589)	(0.298)	(0.910)	(0.473)	(0.302)
P val boys=girls	0.0486**	0.226	0.00***	0.449	0.00943***
Mean of outcome	0.0808	0.411	13.31	0.842	0.632
	Panel C: Non-Poor Children				
Conceived when TRI Site is	-1.326***	0.627**	-4.386**	-0.277	-0.849***
Open (Compared to Closed)	(0.499)	(0.248)	(0.827)	(0.482)	(0.273)
	Panel D: Low-Income Children				
Conceived when TRI Site is	-1.636***	0.714***	-4.667***	-0.323	-0.881***
Open (Compared to Closed)	(0.533)	(0.272)	(0.861)	(0.479)	(0.287)
P val non-poor=low income	0.0698*	0.0615*	0.0001***	0.654	0.0105**
Mean of outcome	0.0808	0.411	13.31	0.842	0.632
	Panel E: Non-Hispanic White Children				
Conceived when TRI Site is	-1.283**	0.502**	-4.594***	-0.300	-0.695***
Open (Compared to Closed)	(0.587)	(0.251)	(1.174)	(0.529)	(0.269)
	Panel F: Black and Hispanic Children				
Conceived when TRI Site is	-1.448***	0.733***	-4.349***	-0.278	-0.945***
Open (Compared to Closed)	(0.502)	(0.229)	(0.964)	(0.491)	(0.238)
P val white=non-white	0.0185**	0.0102**	0.0319**	0.651	0.00382***
Observations	3613	3427	3126	3432	3398
Mean of outcome	0.0808	0.411	13.31	0.842	0.632

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panels A and B, we estimate the effects by gender, and Panels C and D show the effects by maternal poverty status in a child's birth year. Panels E and F estimate the effects by race. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. Standard errors are clustered at the site level. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 5: Heterogeneity in Long Run Outcomes by Parental Exposure, Years of Exposure, or Using the Original TRI Data without Imputation

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Parents Are Employed in a Possible TRI-related Industry				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.342**	0.581*	-4.353***	-0.324	-0.869***
	(0.616)	(0.303)	(0.956)	(0.482)	(0.278)
Conceived when TRI site is Open and Parents Job is Possibly TRI site-related	-1.130*	0.524*	-4.151***	-0.169	-0.811**
	(0.623)	(0.311)	(1.063)	(0.449)	(0.329)
Observations	3613	3427	3126	3432	3398
P val of difference	0.0651*	0.102	0.0022***	0.406	0.0222**
Mean of outcome	0.0808	0.411	13.31	0.842	0.632
	Panel B: Using Only Data from 1980-1998 (post de-leading)				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.438**	0.121	0.603***	-4.671***	-0.332
	(0.705)	(0.298)	(0.192)	(0.974)	(0.594)
Observations	3073	2155	2845	2679	2985
	Panel C: Using Only TRI Data (No Imputations from Tax Records)				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.346**	0.605*	-4.307***	-0.269	-0.834***
	(0.523)	(0.354)	(0.795)	(0.470)	(0.238)
Observations	3642	3450	3148	3459	3424
Mean of outcome	0.0832	0.409	13.31	0.843	0.632

Notes: Columns 1-5 present the results for different long-run outcome variables from exposure to a TRI Site opening. Panel A depicts results for an interaction between being exposed prenatally to TRI pollution and having a parent whose job is potentially in a TRI site. Panel B shows the results when only using data from 1980 to 1998. The results in Panel C show the results from our primary specification when we do not impute opening and closing dates from tax records and just use the raw data. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 6: Average Difference in Family and Zip Code Characteristics between Siblings Living Near 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 Drank During Pregnancy	(8) Ever Attended Preschool	(9) HOME Score	(10) Moved Between Births
	Panel A: Average Difference in Family Characteristics between Children in the Same Zip Code									
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	0.662**	-2.973	-2.040	0.490	3.107*	2.675***	0.0808	0.663	1.622	-0.0113
	(0.270)	(2.011)	(1.684)	(0.449)	(1.800)	(0.585)	(0.647)	(0.542)	(5.783)	(0.227)
Observations	3613	2944	1784	3613	3613	3611	3613	3613	4102	3613
Mean of outcome	0.581	0.653	12.07	0.267	0.581	2.592	0.579	0.579	46.80	0.345
	Panel B: Average Difference in in Zip-code level Characteristics between Children in the Same Zip Code									
	(11) Median Home Value	(12) Median Household Income	(13) Percent Black	(14) Percent Hispanic	(15) Percent of Homes Rented					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-100.1	332.4**	0.00368	0.0137	-0.00338**					
	(65.01)	(148.5)	(0.00606)	(0.0187)	(0.00157)					
Observations	2656	3414	3414	3414	3414					
Mean of outcome	101830.7	37466.2	0.214	0.119	0.342					

Notes: Columns 1-10 present the results for running our main specification where the outcomes are different family characteristics before versus after a TRI site opening. Columns 11-15 present the results where the outcomes are different zip code characteristics experienced between children in the same zip code. Standard errors are adjusted for clustering at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table 7: Long-Run Outcomes for Children Conceived Near a TRI site, Limiting to TRI Sites with Pollution Below the 80th Percentile for TRI Sites Nationally or Without Bad-Sounding Names

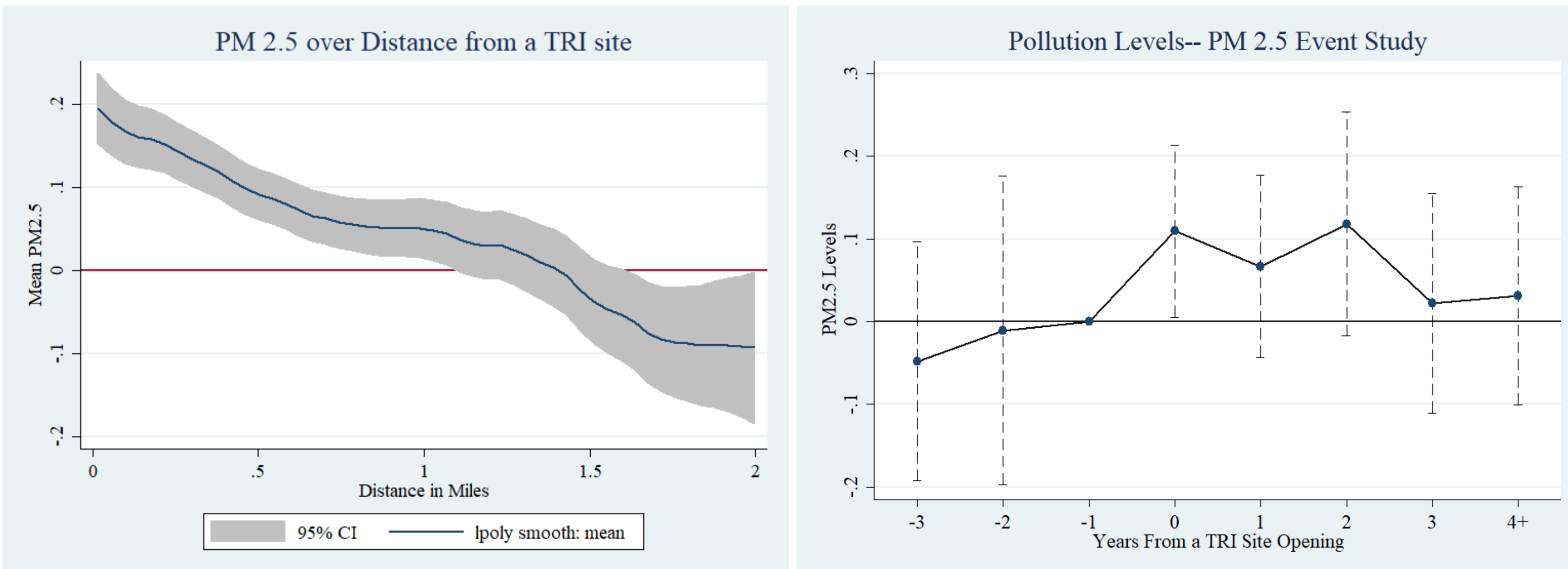
	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Limiting to TRI Sites with Pollution Below the 80th Percentile for TRI Sites Nationally				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.321**	0.652**	-4.198***	-0.266	-0.821***
	(0.586)	(0.287)	(0.932)	(0.503)	(0.276)
Observations	2855	2710	2493	2727	2699
Mean of outcome	0.0580	0.423	13.25	0.838	0.622
	Panel B: Limiting to TRI Sites without Bad-Sounding Names				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.242***	0.703***	-4.064***	-0.231	-0.787***
	(0.390)	(0.256)	(0.805)	(0.436)	(0.250)
Observations	3442	3265	2977	3264	3233
Mean of outcome	0.0716	0.412	13.28	0.839	0.628

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panel A, we restrict to TRI sites with pollution emissions that are below the 80th percentile nationally for TRI sites. In Panel B, we restrict to TRI sites that do not have bad-sounding names. The estimates are from our preferred specification in which the location of the first birth near a TRI site is used for all other children in the same family. Standard errors are adjusted for clustering at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. 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 and Event Study of Particulate Matter after a TRI site Opening

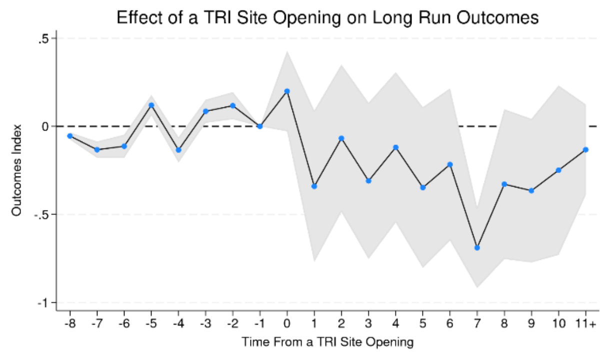
Panel A Panel B



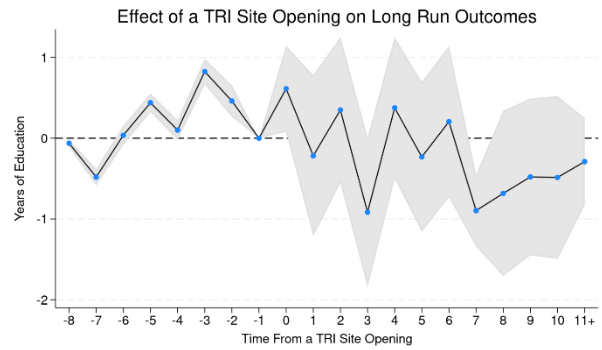
Notes: Panel A of Figure 1 depicts the level of Fine Particulate Matter (PM 2.5) over distance from the TRI site using data from 1990 to 2012. We show pollution levels by calculating the distance between PM 2.5 EPA monitors and the open TRI sites, regressing a kernel-weighted local polynomial smoothed plot of the average PM2.5 in standard deviations measured at a monitor on distance from a TRI site. Panel B of Figure 1 plots the coefficients from a regression of mean level of PM2.5 on leads and lags of a TRI site opening within a mile of the pollution monitor using pollution data from 1999 to 2012. 0 is the year the TRI site opens and all coefficients are normalized such that the coefficient in the year prior to opening (-1) is zero. Dotted lines represent 0.95 confidence intervals for the coefficients. Standard errors are clustered at the pollution monitor level.

Figure 2: Stacked Event Study of Long-Run Outcomes with Zip Code Fixed Effects after a TRI site Opening

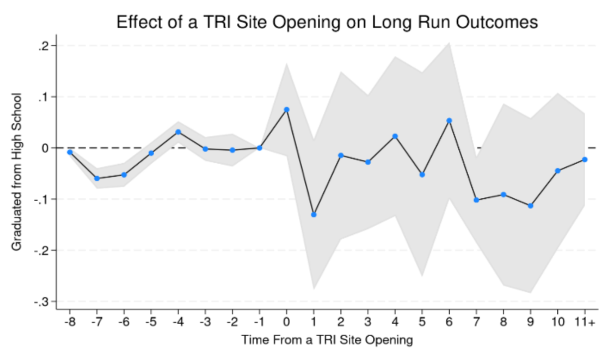
Panel A: Outcomes Index



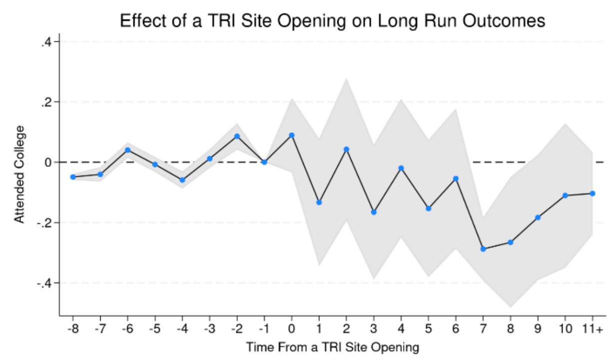
Panel B: Years of Education



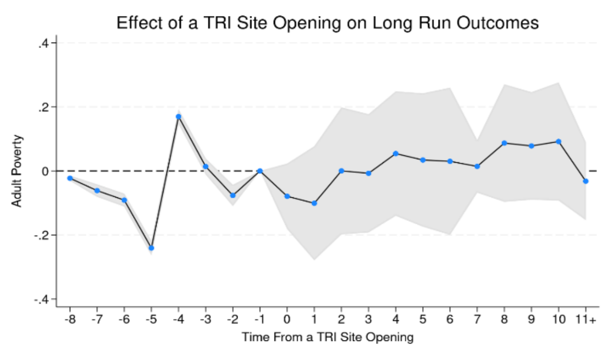
Panel C: Graduated High School



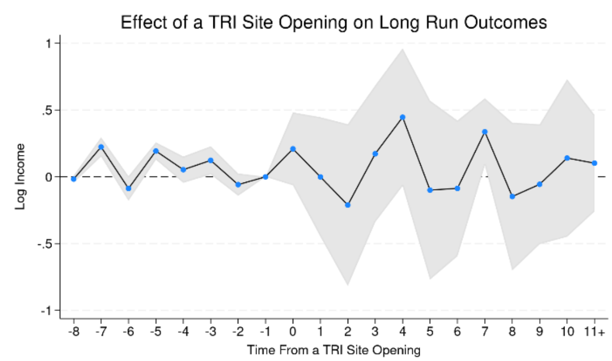
Panel D: Attended College



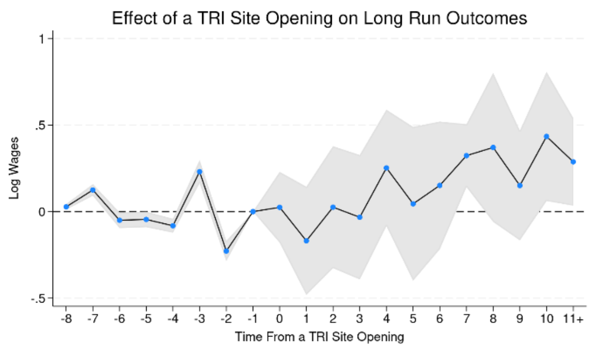
Panel E: On Public Assistance



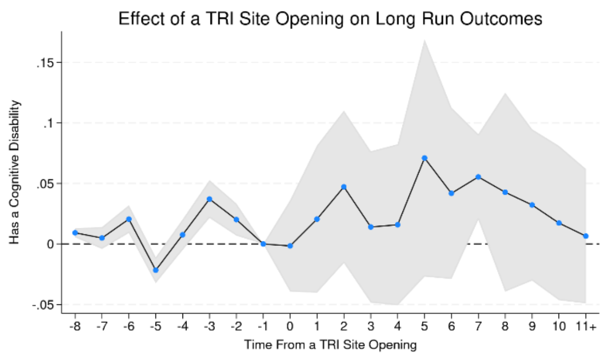
Panel F: Log Income



Panel G: Log Wages



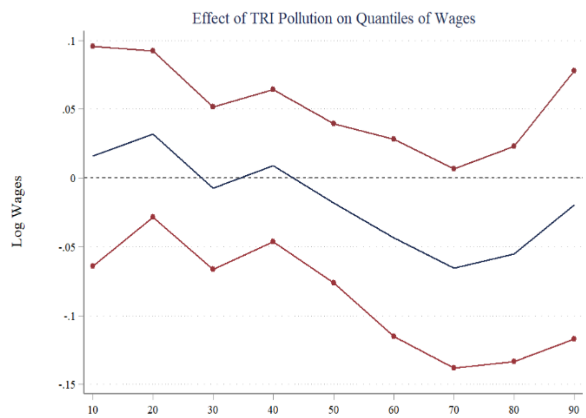
Panel F: Cognitive Disability



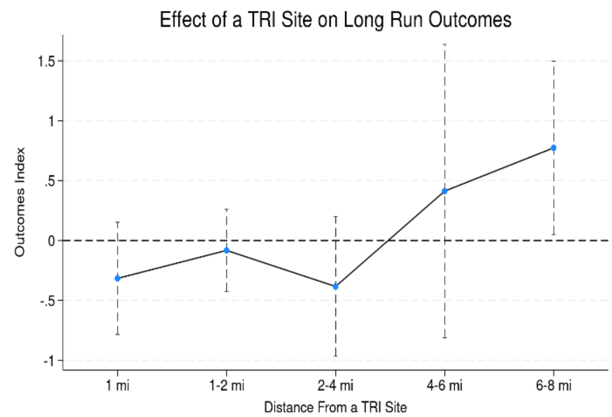
Notes: Figure 2 plots the coefficients from regressions of different long-run outcomes on leads and lags of a TRI site opening using a stacked event study design. 0 is the year the TRI site opens and all coefficients are normalized such that the coefficient in the year prior to opening (-1) is zero. The estimates are from our preferred specification in which we use a stacked event study with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Dotted lines represent 0.95 confidence intervals for the coefficients. Standard errors are clustered at the zip code level.

Figure 3: Effects of in Utero Exposure to TRI Pollution over Quantiles of Income and Outcomes for Gestational Exposure at Different Distances from a TRI site

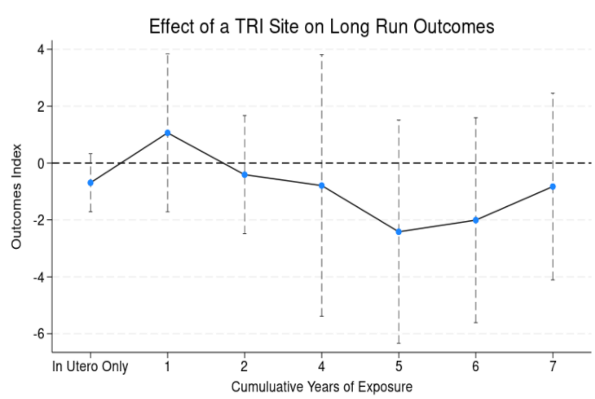
Panel A



Panel B



Panel C



Panel D

Notes: Panel A of Figure 3 plots the effects of gestational exposure to TRI pollution on quantiles of the log of wages in adulthood. The line represents point estimates from a simultaneous quantile regression of the effects of gestational exposure to TRI pollution on wages, controlling for zip code fixed effects, birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. The two red lines represent 95% confidence intervals from bootstrapped standard errors. Panel B of Figure 2 plots the effects of in utero exposure to an operating TRI site at different distances away from the site. Panel C plots the effects of cumulative years of exposure to TRI sites. Panel D plots the effects of TRI pollution from exposure at different ages in childhood. Panels A, C and D use a stacked difference in differences design. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Standard errors are adjusted for clustering at the site level; the vertical lines represent 95 percent confidence intervals.

For Online Publication
Appendix A: Additional Results using TRI Openings

Table A1: Correlation between Conception and TRI Openings and Closings

	(1) Conception Year
Year TRI Opens	0.00423
	(0.0826)
Year TRI Closes	0.108
	(0.148)
Observations	4122
Mean of outcome	0.123

Notes: Column 1 presents the results of a correlational analysis of conception start dates on TRI openings and closings. Standard errors are adjusted for clustering at the site level. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, age squared, age cubed, maternal marriage status, total years of childhood poverty, maternal drinking, adult marital status 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.

Table A2: Results using Alternative Specifications and Samples

	(1) Outcomes Index	(2) Log Wages	(3) On Public Assistance	(4) Years of Education	(5) Completed High School	(6) Attended College
	Panel A: Callaway and Sant'Anna Estimates					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-2.431***	-1.885***	-0.168	-6.31	-0.342	-1.346***
	(0.785)	(0.479)	(0.535)	(4.84)	(0.609)	(0.542)
Observations	945	551	1,317	861	874	874
	Panel B: Main Results with No Controls					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.577***	0.103	0.207	-5.038***	-0.290	-0.851**
	(0.364)	(0.229)	(0.435)	(0.944)	(0.947)	(0.402)
Observations	3953	2630	4253	3241	3568	3533
	Panel C: County-level Stacked DID					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.342	0.0379	0.337	-1.212	-0.0721	-0.179
	(0.510)	(0.479)	(0.263)	(1.615)	(0.203)	(0.280)
Observations	3613	2538	3427	3126	3432	3398
Mean of Outcome	0.0808	2.368	0.411	13.31	0.842	0.632

Notes: Columns 1-6 present the results for different long-run outcome variables. Panel A shows the results when using Callaway and Sant'Anna's dynamic difference in differences estimator (csdid). Panel B presents results with no controls except for family, birth month, birth year and birth order fixed effects. Panel C shows results when using county fixed effects rather than zip code fixed effects. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table A3 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) Ever Married	(5) Low Birth Weight	(6) PIAT Math Score	(7) PIAT Reading Score	(8) Behavioral Problems Index Score	(9) Digit Score
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.119	0.0368	0.266	-0.0905	0.0382	-10.35**	-7.235**	40.62**	-0.158
	(0.155)	(0.171)	(0.360)	(0.248)	(0.162)	(4.608)	(2.997)	(20.27)	(1.852)
Observations	3699	4122	3931	3778	3490	3942	3934	4083	3726
Mean of outcome	0.478	0.119	0.221	0.319	0.0825	37.73	41.04	58.57	9.716

Notes: Columns 1-9 present the results for different long-run outcome variables. Standard errors are adjusted for clustering at the site level. These estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table A4: Mediation Analysis

	(1) Outcomes Index	(2) Outcomes Index	(3) Outcomes Index	(4) Outcomes Index
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.378***	-1.804**	0.291	-1.839***
	(0.353)	(0.855)	(0.237)	(0.574)
Cognitive Disability	-2.307***			
	(0.335)			
Employed		0.912***		
		(0.134)		
Years of Education			0.369***	
			(0.0161)	
Low Birth Weight				-0.0280
				(0.245)
Observations	3613	3613	3126	3358
Mean of Outcome	0.0870	0.0870	0.0870	0.0870

Notes: Columns 1-4 present results for the outcomes index when mediated by different possible channels. Standard errors are clustered at the TRI site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table A5: The Effects of TRI Pollution by Industry, Pollution Type and Amount of Pollution

	Outcomes Index		
	(1) All other Industries	(2) Metals, Plastic, Mechanical and Chemicals	(3) Power Plants
	Panel A: Types of Industry		
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.959**	-0.967*	-3.385***
	(0.398)	(0.557)	(0.892)
Observations	1756	2137	350
	Panel B: Types of Pollution		
	(4) No Heavy Metals		
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.389**		
	(0.546)		
Observations	3576		
	Panel C: Amounts of Pollution		
	(5) Less than Median Amounts	(6) More than Median Amounts	
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-3.631***	-7.082**	
	(0.878)	(2.998)	
Observations	446	438	

Notes: Panel A of this table includes output from different regressions in which the effects of exposure to different types of TRI industries during gestation were estimated on the long run outcomes index. Panel B of this table also includes output from a single regression in which we estimated the effects of exposure to pollution that did not include heavy metals during gestation on long run outcomes. Panel C shows the effects of above versus below median amounts of pollution on the outcomes index. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

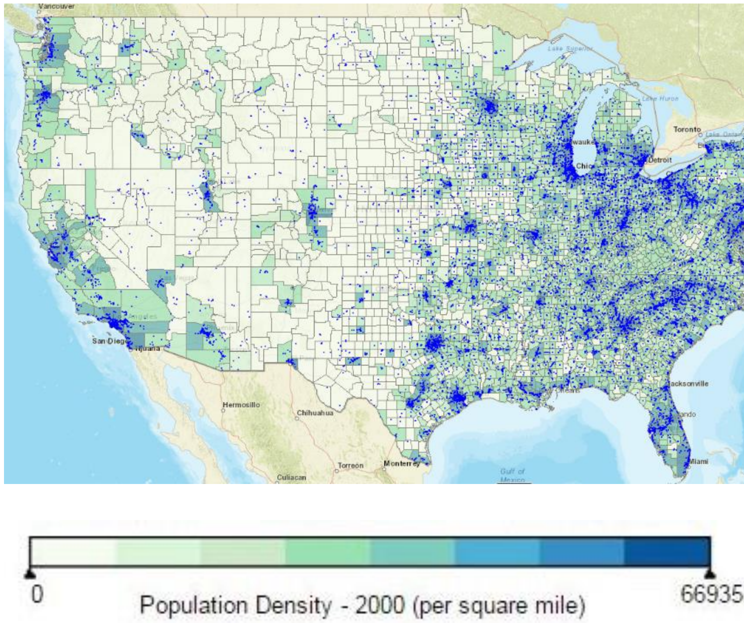
Table A6: Correlation Between the Number of Times a Child is Observed in the Data and Child Characteristics

	(1) Black	(2) Hispanic	(3) Female	(4) Poverty Status in Birth Year	(5) Maternal Marriage Status	(6) Years of Childhood Poverty
Number of times in the data	0.0115	0.0183	0.00894	-0.000585	-0.000425	0.0155
	(0.0200)	(0.0157)	(0.0237)	(0.0209)	(0.0229)	(0.221)
N	4351	4351	4351	4351	4351	4351
Mean of outcome	0.302	0.174	0.465	0.268	0.596	3.099

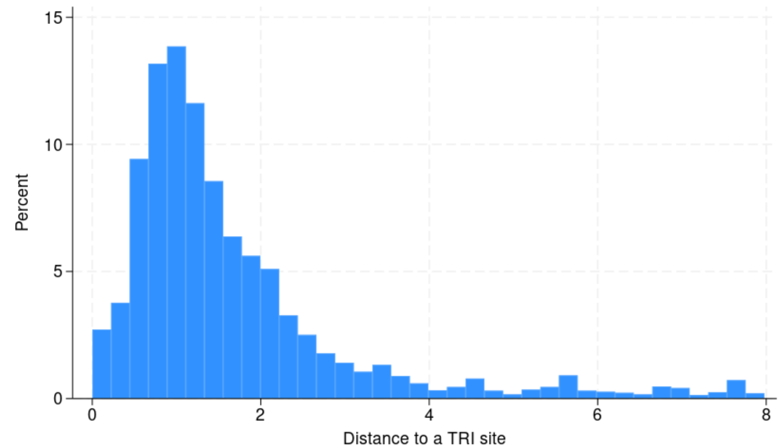
Notes: Columns 1-6 present the results of a correlational analysis of different child characteristics on the number of times that child appears in the data. Standard errors are adjusted for clustering at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Figure A1: TRI Sites over Population Density

Panel A: TRI Sites over Population Density



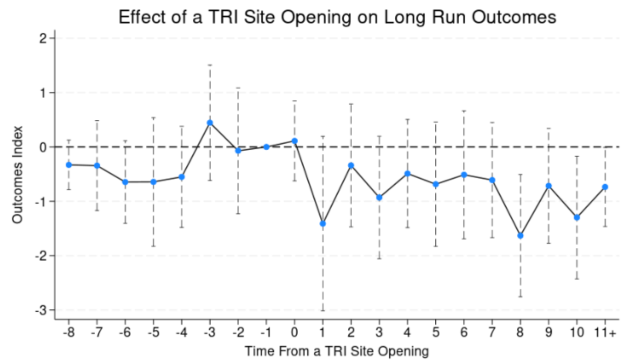
Panel B: Percent of Children Living Different Distances from a TRI Site



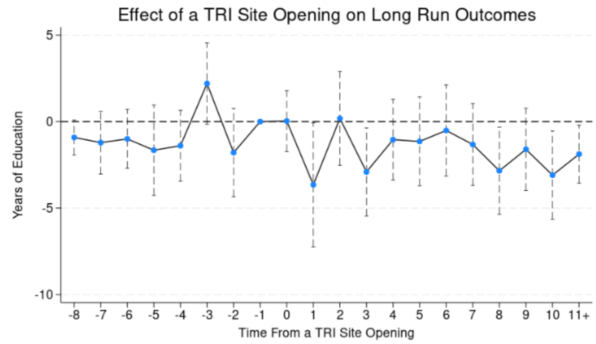
Notes: Panel A of Figure A1 shows the location of TRI sites (blue dots) nationally (according to the National Institute of Health's Toxmap website, 2019) overlaid on a population density map by county. Darker blue areas are more population dense. TRI sites are disproportionately located in the most population 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/ Panel B of Figure A1 shows the percentage of children living different distances from a TRI site in our sample. Less than 1% of children live more than 8 miles away, so we limited the figure's sample to children within 8 miles for clarity.

Figure A2: Stacked Event Study of Long-Run Outcomes with Zip Code Fixed Effects after a TRI site Opening for Children Living Within a Mile of a TRI Site

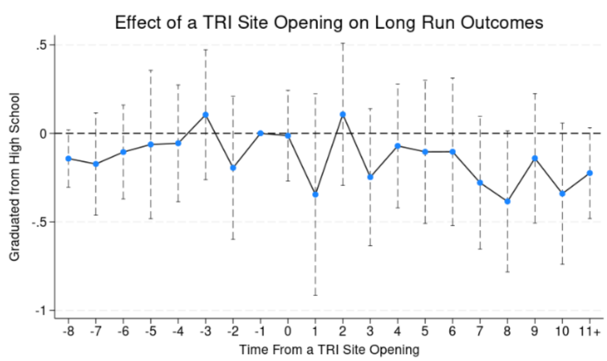
Panel A: Outcomes Index



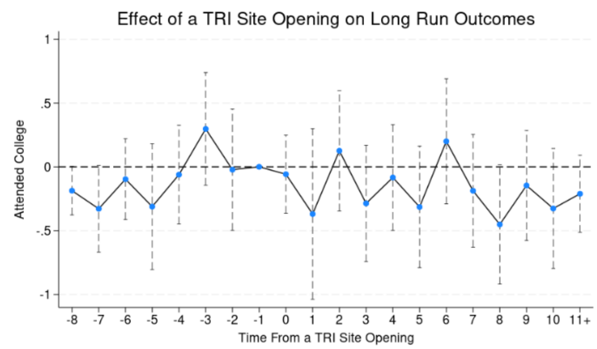
Panel B: Years of Education



Panel C: Graduated High School

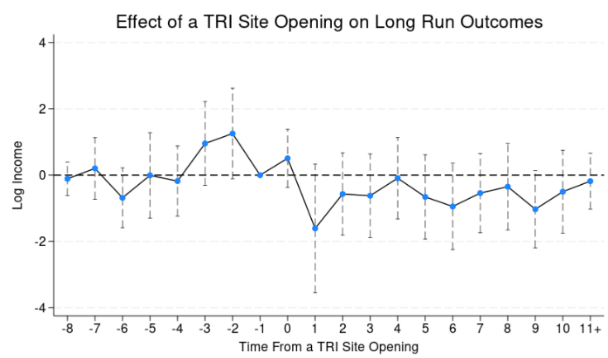


Panel D: Attended College

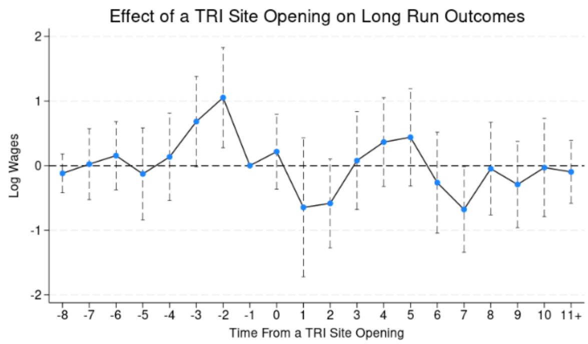


Panel E: On Public Assistance

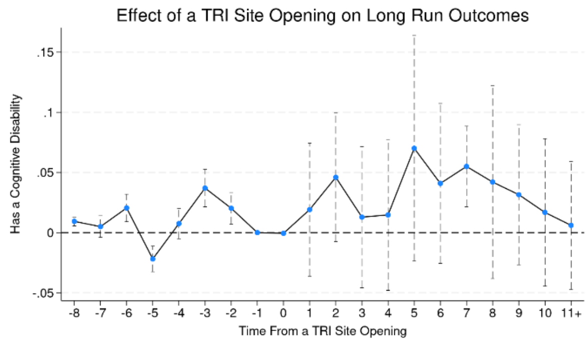
Panel F: Log Income



Panel G: Log Wages



Panel F: Cognitive Disability



Notes: Figure A2 plots the coefficients from regressions of different long-run outcomes on leads and lags of a TRI site opening using a stacked event study design. 0 is the year the TRI site opens and all coefficients are normalized such that the coefficient in the year prior to opening (-1) is zero. The estimates are from our preferred specification in which we use a stacked event study with zip code fixed effects. Only non-moving children residing within 1 mile of TRI site are included in this sample. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Dotted lines represent 0.95 confidence intervals for the coefficients. Standard errors are clustered at the zip code level.

Appendix B: Additional Results using TRI site Closings

Table B1: Long-Run Outcomes by Gender, Race and Poverty Status at Birth

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Boys				
Conceived when TRI Site is	-1.419***	0.440	-4.757***	-0.405	-0.860***
Open (Compared to Closed)	(0.507)	(0.311)	(0.761)	(0.429)	(0.248)
	Panel B: Girls				
Conceived when TRI Site is	-1.357**	0.633**	-4.033***	-0.267	-0.812***
Open (Compared to Closed)	(0.534)	(0.306)	(0.874)	(0.431)	(0.261)
P val boys=girls	0.0227**	0.486	0.00***	0.234	0.00***
Mean of outcome	0.101	0.401	13.37	0.850	0.639
	Panel C: Non-Poor Children				
Conceived when TRI Site is	-1.335***	0.547**	-4.308***	-0.317	-0.830***
Open (Compared to Closed)	(0.483)	(0.250)	(0.824)	(0.478)	(0.258)
	Panel D: Low-Income Children				
Conceived when TRI Site is	-1.612***	0.554**	-4.555***	-0.379	-0.848***
Open (Compared to Closed)	(0.538)	(0.277)	(0.904)	(0.478)	(0.286)
P val non-poor=low income	0.0514*	0.0660*	0.00**	0.619	0.006***
Mean of outcome	0.101	0.401	13.37	0.850	0.639
	Panel E: Non-Hispanic White Children				
Conceived when TRI Site is	-1.436**	0.530*	-4.823***	-0.393	-0.738**
Open (Compared to Closed)	(0.634)	(0.289)	(1.286)	(0.560)	(0.289)
	Panel F: Black and Hispanic Children				
Conceived when TRI Site is	-1.349**	0.561**	-4.057***	-0.287	-0.893***
Open (Compared to Closed)	(0.531)	(0.267)	(1.039)	(0.515)	(0.244)
P val white=non-white	0.0847*	0.183	0.129	0.761	0.0152**
Mean of outcome	0.101	0.401	13.37	0.850	0.639
Observations	3189	3027	2752	3022	2990

Notes: Columns 1-5 present the results for TRI site closings for different long-run outcome variables. In Panels A and B, we estimate the effects by gender, and Panels C and D show the effects by maternal poverty status in a child's birth year. Panels E and F estimate the effects by race. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. Standard errors are clustered at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B2: Heterogeneity in Long Run Outcomes by Parental Exposure, Years of Exposure, or Using the Original TRI Data without Imputation

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Parents Are Employed in a Possible TRI-related Industry				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.372**	0.483	-4.336***	-0.377	-0.846***
	(0.578)	(0.297)	(0.909)	(0.473)	(0.271)
Conceived when TRI site is Open and Parents Job is Possibly TRI site-related	-0.890	0.499	-3.574***	-0.200	-0.671*
	(0.659)	(0.317)	(1.289)	(0.449)	(0.353)
Observations	3189	3027	2752	3022	2990
P val of difference	0.0440**	0.243	0.0019***	0.372	0.0289**
Mean of outcome	0.101	0.401	13.37	0.850	0.639
	Panel B: Using Only TRI Data (No Imputations from Tax Records)				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.347**	0.523	-4.297***	-0.301	-0.851***
	(0.526)	(0.341)	(0.824)	(0.499)	(0.229)
Observations	3143	2984	2707	2973	2942
Mean of outcome	0.109	0.397	13.39	0.852	0.643

Notes: Columns 1-5 present the results for different long-run outcome variables from exposure to a TRI Site opening. Panel A depicts results for an interaction between being exposed prenatally to TRI pollution and having a parent whose job is potentially in a TRI site. The results in Panel B show the results from our primary specification when we do not impute opening and closing dates from tax records and just use the raw data. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B3: Average Difference in Family and Zip Code 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 Drank During Pregnancy	(8) Ever Attended Preschool	(9) HOME Score	(10) Moved Between Births
	Panel A: Average Difference in Family Characteristics between Children in the Same Zip Code									
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	0.671**	-3.112	-2.196	0.490	3.721**	2.377***	-0.0148	0.535	1.994	-0.0489
	(0.314)	(1.913)	(2.047)	(0.435)	(1.845)	(0.665)	(0.597)	(0.454)	(10.33)	(0.161)
Observations	3189	2598	1562	3189	3189	3196	3189	3189	3625	3645
Mean of outcome	0.585	0.659	12.13	0.262	0.585	2.599	0.590	0.590	47.51	0.31
	Panel B: Average Difference in in Zip-code level Characteristics between Children in the Same Zip Code									
	(11)	(12)	(13)	(14)	(15)					
	Median Home Value	Median Household Income	Percent Black	Percent Hispanic	Percent of Homes Rented					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	14.90	465.7	0.0192*	0.0273	-0.00258					
	(12.13)	(365.7)	(0.0103)	(0.0338)	(0.00293)					
Observations	2343	3011	3011	3011	3011					
Mean of outcome	103144.1	38035.8	0.204	0.119	0.342					

Notes: Columns 1-10 present the results for TRI closings when running our main specification where the outcomes are different family characteristics before versus after a TRI site closing. Columns 11-15 present the results where the outcomes are different zip code characteristics experienced between children in the same zip code. Standard errors are adjusted for clustering at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B4: Long-Run Outcomes 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) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) 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)	-1.273**	0.546*	-3.982***	-0.288	-0.771***
	(0.556)	(0.290)	(0.905)	(0.500)	(0.264)
Observations	2508	2379	2188	2396	2369
Mean of outcome	0.0843	0.412	13.33	0.848	0.631
	Panel B: Limiting to TRI Sites without Bad-Sounding Names				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.169***	0.591**	-3.947***	-0.263	-0.768***
	(0.395)	(0.235)	(0.838)	(0.451)	(0.252)
Observations	3021	2866	2604	2857	2828
Mean of outcome	0.0919	0.402	13.33	0.847	0.635

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panel A, we restrict to TRI sites with pollution emissions that are below the 80th percentile nationally for TRI sites. In Panel B, we restrict to TRI sites that do not have bad-sounding names. The estimates are from our preferred specification in which the location of the first birth near a TRI site is used for all other children in the same family. Standard errors are adjusted for clustering at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B5: Results using Alternative Specifications and Samples

	(1) Outcomes Index	(2) Log Wages	(3) On Public Assistance	(4) Years of Education	(5) Completed High School	(6) Attended College
	Panel A: Main Results with No Controls					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.733***	0.0423	0.193	-5.591***	-0.362	-0.943**
	(0.294)	(0.234)	(0.437)	(0.612)	(1.060)	(0.393)
Observations	3493	2335	3769	2859	3149	3116
	Panel B: Using Only Data from 1980-1998 (post de-leading)					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.387**	-0.00694	0.479***	-4.500***	-0.378	-0.831***
	(0.675)	(0.335)	(0.169)	(0.914)	(0.578)	(0.261)
Observations	2718	1913	2518	2363	2633	2601
	Panel C: County Fixed Effects					
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.318	0.00336	0.288	-1.201	-0.0707	-0.183
	(0.512)	(0.473)	(0.249)	(1.602)	(0.212)	(0.261)
Observations	3189	2250	3027	2752	3022	2990
Mean of Outcome	0.101	2.375	0.401	13.37	0.850	0.639

Notes: Columns 1-6 present the results for different long-run outcome variables. Panel A shows the results when using Callaway and Sant'Anna's dynamic difference in differences estimator (csdid). Panel B presents results with no controls except for family, birth month, birth year and birth order fixed effects. Panel D shows results when using county fixed effects rather than zip code fixed effects. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B6: 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) Ever Married	(5) Low Birth Weight	(6) PIAT Math Score	(7) PIAT Reading Score	(8) Behavioral Problems Index Score	(9) Digit Score
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.145	-0.0153	0.335	-0.141	0.0818	-10.76**	-7.418**	33.76*	-0.204
	(0.174)	(0.203)	(0.340)	(0.252)	(0.180)	(4.299)	(3.059)	(19.23)	(1.984)
Observations	3264	3645	3474	3338	3078	3477	3469	3608	3280
Mean of outcome	0.476	0.120	0.220	0.324	0.0776	37.85	41.15	57.99	9.779

Notes: Columns 1-6 present the results for different long-run outcome variables. Standard errors are adjusted for clustering at the site level. These estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B7: Mediation Analysis

	(1) Outcomes Index	(2) Outcomes Index	(3) Outcomes Index	(4) Outcomes Index
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.331***	-1.811**	0.258	-1.813***
	(0.352)	(0.886)	(0.245)	(0.610)
Cognitive Disability	-2.295***			
	(0.337)			
Employed		0.930***		
		(0.142)		
Years of Education			0.367***	
			(0.0167)	
Low Birth Weight				0.0212
				(0.269)
Observations	3189	3189	2752	2961
Mean of Outcome	0.101	0.101	0.101	0.101

Notes: Columns 1-4 present results for the outcomes index when mediated by different possible channels. Standard errors are clustered at the TRI site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Table B8: The Effects of TRI Pollution by Industry, Pollution Type and Amount of Pollution

	Outcomes Index		
	(1) All other Industries	(2) Metals, Plastic, Mechanical and Chemicals	(3) Powerplants
	Panel A: Types of Industry		
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.807* (0.440)	-0.898 (0.577)	-3.363*** (1.272)
Observations	1526	1917	303
	Panel B: Types of Pollution		
	(4) No Heavy Metals		
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1.387*** (0.521)		
Observations	3155		
	Panel C: Amounts of Pollution		
	(5) Less than Median Amounts	(6) More than Median Amounts	
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-3.631*** (0.878)	-7.082** (2.998)	
Observations	446	438	

Notes: Panel A of this table includes output from different regressions in which the effects of exposure to different types of TRI industries during gestation were estimated on the long run outcomes index. Panel B of this table also includes output from a single regression in which we estimated the effects of exposure to pollution that did not include heavy metals during gestation on long run outcomes. Panel C shows the effects of above versus below median amounts of pollution on the outcomes index. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

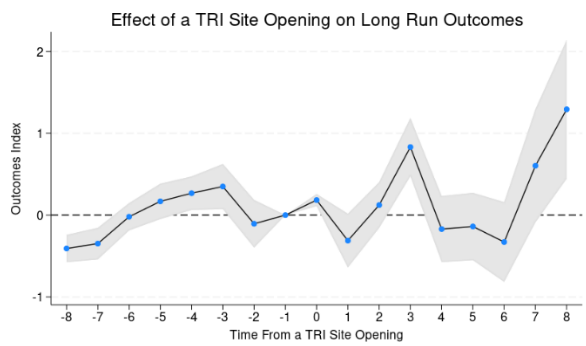
Table B9: Correlation Between the Number of Times a Child is Observed in the Data and Child Characteristics

	(1) Black	(2) Hispanic	(3) Female	(4) Poverty Status in Birth Year	(5) Maternal Marriage Status	(6) Years of Childhood Poverty
Number of times in the data	0.0115	0.0183	0.00894	-0.000585	-0.000425	0.0155
	(0.0200)	(0.0157)	(0.0237)	(0.0209)	(0.0229)	(0.221)
N	4351	4351	4351	4351	4351	4351
Mean of outcome	0.302	0.174	0.465	0.268	0.596	3.099

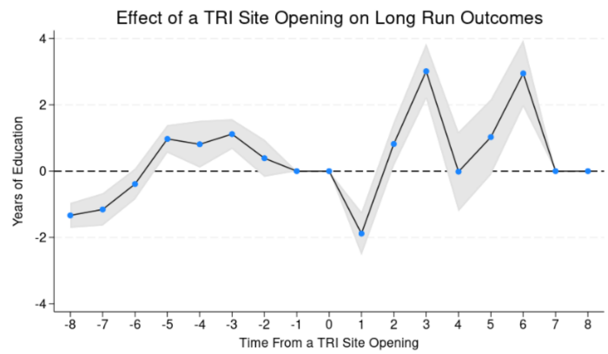
Notes: Columns 1-6 present the results of a correlational analysis of different child characteristics on the number of times that child appears in the data. Standard errors are adjusted for clustering at the site level. The estimates are from our preferred specification in which we use stacked differences in differences with zip code fixed effects. In addition to zip code fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, maternal education, poverty status in the birth year, total years of childhood poverty, preschool attendance, whether the family moved, race and gender. All regressions are weighted by the inverse of the distance to the closest TRI site. Coefficients labeled as ***, **, and * are statistically significant at the 1, 5, and 10 percent levels, respectively.

Figure B1: Stacked Event Study of Long-Run Outcomes with Zip Code Fixed Effects after a TRI site Closing

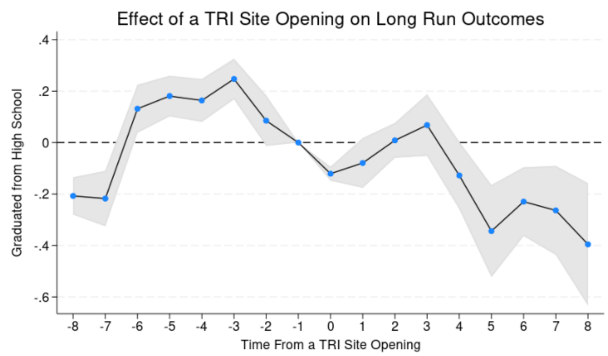
Panel A: Outcomes Index



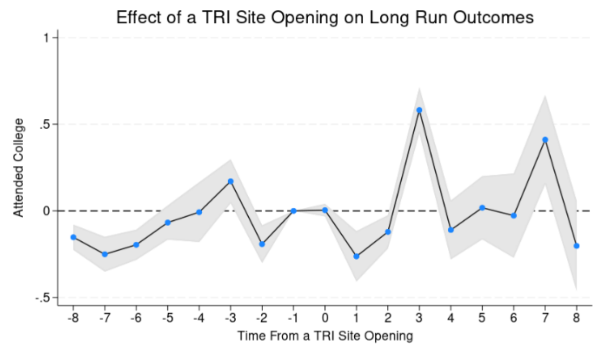
Panel B: Years of Education



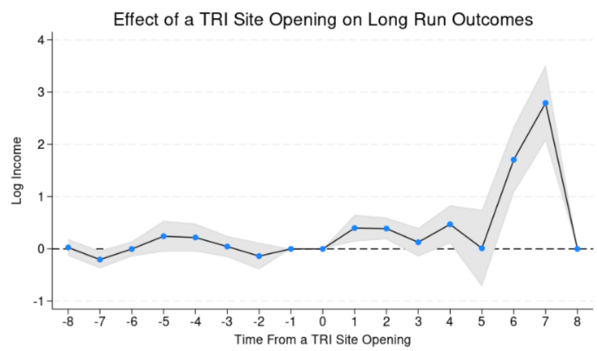
Panel C: Graduated High School



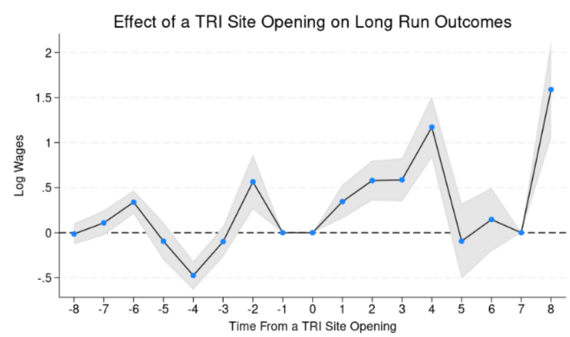
Panel D: Attended College



Panel E: Log Income



Panel F: Log Wages



Notes: Figure B1 plots the coefficients from a regression of different long-run outcomes on leads and lags of a TRI site opening using a stacked event study design. 0 is the year the TRI site opens and all coefficients are normalized such that the coefficient in the year prior to opening (-1) is zero. In addition to zip code fixed effects, the regression controls for birth year, birth order and birth month fixed effects, gender, and age. Dotted lines represent 0.95 confidence intervals for the coefficients. Standard errors are clustered at the zip code level.

Appendix C: Results with Family Fixed Effects within 1 Mile of a TRI Site

Table C1: 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	(4) Characteristics of Children Within 1 Mile of a TRI Site (main sample)	(5) Characteristics of Moving Families	(6) Characteristics of Non-Moving Families
Maternal Education at Birth	12.87	12.38	12.37	12.46	12.97	12.29
Paternal Education at Birth	12.64	12.47	12.51	12.55	12.75	12.48
Mother was in Poverty in Birth Year	0.168	0.254	0.269	0.263	0.256	0.265
Years of Education in Adulthood	13.69	13.28	13.49	13.31	13.47	13.26
Percent Black	0.157	0.214	0.212	0.215	0.206	0.218
Percent Hispanic	0.080	0.167	0.159	0.148	0.188	0.137
Maternal Marriage Status	0.744	0.606	0.610	0.592	0.647	0.576
Attended Preschool	0.662	0.622	0.613	0.620	0.643	0.613
Age of Oldest Observed Wage	28.74	26.38	26.58	29.01	28.26	29.23
Years Exposed to TRI Pollution if Respondent Does not Move Away	1.564	5.067	10.60	6.554	3.075	7.541
Observations	11,521	2,260	1,082	1,704	339	1,365

Notes: This table depicts the mean 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. Column 4 shows characteristics of children in the main sample in which the first sibling is within 1 mile of a TRI site at birth. Column 5 shows the characteristics of moving families in the main sample. Column 6 shows characteristics of non-moving families.

Table C2: Long-Run Outcomes Index for Children Conceived Within One Mile of a TRI Site

	(1) Outcomes Index (Within 1 mile vs 5+ miles away)	(2) Outcomes Index (Within 1 mile vs 5+ miles away)	(3) Outcomes Index (Within 1 mile vs 5+ miles away)	(4) Outcomes Index (Within 1 mile)	(5) Outcomes Index (Within 1 mile)	(6) Outcomes Index (Within 1 mile)	(7) Outcomes Index (Within 1 mile using non-moving families)
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	0.00235	-0.0193	-0.144	-0.200	-0.407***	-0.563***	-0.572***
	(0.0479)	(0.123)	(0.152)	(0.121)	(0.130)	(0.175)	(0.161)
Observations	2751	2751	2751	1704	1704	1704	1,399
Mean of outcome	0.0671	0.0671	0.0671	0.0913	0.0870	0.0870	0.123
Using Plant Openings and Closings		X	X	X	X	X	X
Zip code Fixed Effects		X		X			
Family Fixed Effects			X		X	X	X
Adjusting for residential sorting (using the location of the first birth)				X	X	X	
TRI site Fixed Effects						X	

Notes: Columns 1-7 present the results for different specifications where the outcome is a long-run outcomes index. Standard errors are adjusted for clustering at the site level. Regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C3: The Effects of Openings versus Closings on Long-Run Outcomes with Family Fixed Effects for Children Conceived Within One Mile of a TRI Site

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Restricted to Openings				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.486***	0.171**	-0.986**	-0.125**	-0.122
	(0.156)	(0.0722)	(0.476)	(0.0529)	(0.0758)
Observations	1629	1589	1324	1456	1435
Mean of outcome	0.0958	0.377	13.34	0.841	0.624
	Panel B: Restricted to Closings				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.424**	-0.00541	-1.041**	0.00280	-0.0985
	(0.198)	(0.0788)	(0.480)	(0.0669)	(0.0940)
Observations	1573	1541	1272	1399	1380
Mean of outcome	0.0829	0.372	13.31	0.834	0.613

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panel A, we restrict to TRI site openings, and in Panel B we restrict to TRI site closings. The estimates are from the preferred specification in which the location of the first birth near a TRI site is used for all other children in the same family. 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C4: Long-Run Outcomes by Gender, Race and Poverty Status at Birth

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Boys				
Conceived when TRI Site is Open (Compared to Closed)	-0.396***	0.115**	-0.642*	-0.0516	-0.0883
	(0.148)	(0.0577)	(0.372)	(0.0615)	(0.0718)
	Panel B: Girls				
Conceived when TRI Site is Open (Compared to Closed)	-0.364**	0.111*	-0.776*	-0.0565	0.0148
	(0.152)	(0.0601)	(0.425)	(0.0605)	(0.0763)
P val boys=girls	0.0597*	0.125	0.338	0.621	0.0970*
Mean of outcome	0.0870	0.374	13.30	0.845	0.616
	Panel C: Non-Poor Children				
Conceived when TRI Site is Open (Compared to Closed)	-0.365***	0.134**	-0.652*	-0.0339	-0.0356
	(0.133)	(0.0564)	(0.373)	(0.0542)	(0.0670)
	Panel D: Low-Income Children				
Conceived when TRI Site is Open (Compared to Closed)	-0.415**	0.0652	-0.787*	-0.118*	-0.0777
	(0.170)	(0.0602)	(0.417)	(0.0710)	(0.0816)
P val non-poor=low income	0.0776*	0.00562***	0.315	0.512	0.946
Mean of outcome	0.0870	0.374	13.30	0.835	0.616
	Panel E: Non-Hispanic White Children				
Conceived when TRI Site is Open (Compared to Closed)	-0.396**	0.0581	-0.936	-0.0324	0.0802
	(0.178)	(0.0617)	(0.643)	(0.0879)	(0.0793)
	Panel F: Black and Hispanic Children				
Conceived when TRI Site is Open (Compared to Closed)	-0.372*	0.161*	-0.568	-0.0707	-0.143*
	(0.190)	(0.0862)	(0.423)	(0.0636)	(0.0840)
P val white=non-white	0.401	0.146	0.846	0.456	0.0416**
Observations	1704	1667	1383	1527	1504
Mean of outcome	0.0870	0.374	13.30	0.835	0.616

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panels A and B, we estimate the effects by gender, and Panels C and D show the effects by maternal poverty status in a child's birth year. Panels E and F estimate the effects by race. The estimates are from our preferred specification in which the location of the first birth near a TRI site is instrumented for all other children in the same family. Standard errors are clustered 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C5: Heterogeneity in Long Run Outcomes by Parental Exposure, Years of Exposure, or Limiting to First and Second Born Children

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Parents Are Employed in a Possible TRI-related Industry				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.442***	0.173***	-0.773*	-0.0804	-0.0785
	(0.144)	(0.0658)	(0.409)	(0.0594)	(0.0743)
Conceived when TRI site is Open and Parents Job is Possibly TRI site-related	-0.248	-0.104	-0.583	0.0168	0.00664
	(0.213)	(0.131)	(0.690)	(0.0774)	(0.103)
Observations	1704	1562	1383	1527	1504
P val of difference	0.0594*	0.00395***	0.348	0.144	0.308
Mean of outcome	0.0870	0.399	13.30	0.835	0.616
	Panel B: Years of Exposure				
	Fewer than 7 Years of Exposure				
Exposed During Gestation + <7 years (Compared to Conceived When TRI site is closed)	-0.330	0.0320	-0.279	0.0609	0.00470
	(0.226)	(0.0811)	(0.510)	(0.0817)	(0.0822)
Observations	988	910	787	878	861
	7 or More Years of Exposure				
Exposed During Gestation + >= 7 years (Compared to Conceived When TRI site is closed)	-0.401**	0.253***	-1.197*	-0.151**	-0.181
	(0.187)	(0.0887)	(0.714)	(0.0715)	(0.111)
Observations	716	652	596	649	643
	Panel C: Limiting to First and Second born Children				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.406**	0.130*	-1.350**	-0.158**	-0.180**
	(0.172)	(0.0750)	(0.644)	(0.0667)	(0.0822)
Observations	1386	1362	1123	1213	1198
Mean of outcome	0.140	0.365	13.45	0.852	0.647

Notes: Columns 1-5 present the results for different long-run outcome variables. Panel A depicts results for an interaction between being exposed prenatally to TRI pollution and having a parent whose job is potentially in a TRI site. Panel B shows results for being exposed prenatally to TRI pollution plus less than 7 years of exposure, versus being exposed prenatally with 7 or more years of exposure (compared to an unexposed sibling). In Panel C, only first and second-born children are included in the analysis in which the location of the first birth is used for other children in the same family. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C6: Average Difference in Family and Zip Code 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
	Panel A: Average Difference in Family Characteristics between Siblings								
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	0.101**	0.0118	0.00663	-0.00749	-0.112	0.234	-0.0138	-0.000***	-0.0787
	(0.0411)	(0.141)	(0.283)	(0.0640)	(0.259)	(0.319)	(0.0511)	(0.000)	(0.0695)
Observations	1704	1379	772	1704	988	1518	1704	988	1561
Mean of outcome	0.545	12.25	12.23	0.281	2.18	2.617	0.268	0.415	0.613
	Panel B: Average Difference in in Zip-code level Characteristics between Siblings								
	(10) Median Home Value	(11) Median Household Income	(12) Percent Black	(13) Percent Hispanic	(14) Percent of Homes Rented	(15) Moved Between Births			
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-1001.6	-114.3	-0.00267	0.0125	-0.00685*	-0.128**			
	(1305.1)	(311.2)	(0.0106)	(0.0106)	(0.00357)	(0.0563)			
Observations	1007	1274	1274	1274	1274	1704			
Mean of outcome	104657.7	35126.7	0.253	0.123	0.388	0.31			

Notes: Columns 1-9 and 15 present the results for running our main specification where the outcomes are different family characteristics. The estimates are from our preferred specification in which the location of the first birth near a TRI site is instrumented for all other children in the same family. Columns 10-14 present the results where the outcomes are different zip code characteristics experienced between siblings. 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C7: 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) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) 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)	-0.400**	0.115*	-0.956**	-0.0925	-0.0358
	(0.162)	(0.0609)	(0.405)	(0.0675)	(0.0735)
Observations	1405	1377	1151	1265	1247
Mean of outcome	0.0795	0.383	13.30	0.839	0.614
	Panel B: Limiting to TRI Sites without Bad-Sounding Names				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.553***	0.0843	-1.102***	-0.0852	-0.0765
	(0.165)	(0.0724)	(0.420)	(0.0665)	(0.0778)
Observations	1473	1443	1193	1320	1300
Mean of outcome	0.0722	0.376	13.23	0.828	0.605

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panel A, we restrict to TRI sites with pollution emissions that are below the 80th percentile nationally for TRI sites. In Panel B, we restrict to TRI sites that do not have bad-sounding names. The estimates are from our preferred specification in which the location of the first birth near a TRI site is used for all other children in the same family. 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C8: Correlation between Conception and TRI Openings and Closings

	(1) Conception Year
Year TRI Opens	-0.0000374
	(0.0000694)
Year TRI Closes	0.000101
	(0.000191)
Observations	1898
Mean of outcome	0.123

Notes: Column 1 presents the results of a correlational analysis of conception start dates on TRI openings and closings. 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, age squared, age cubed, maternal marriage status, total years of childhood poverty, maternal drinking, adult marital status 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.

Table C9: Results with No Controls, Alternative Samples, and Outcomes Index Results without Including Educational Outcomes

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Main Results with No Controls				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.405***	0.133*	-0.801**	-0.0773	-0.0568
	(0.134)	(0.0764)	(0.350)	(0.0610)	(0.0715)
Observations	1704	1562	1383	1527	1504
	Panel B: Using Only TRI Data (No Imputations from Tax Records)				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.472**	0.0781	-1.239**	-0.0581	-0.153
	(0.197)	(0.0992)	(0.531)	(0.0700)	(0.101)
Observations	992	907	799	875	864
	Panel C: Using Only Data from 1980-1998				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.339**	0.117*	-0.568	-0.0415	-0.0436
	(0.133)	(0.0661)	(0.390)	(0.0562)	(0.0663)
Observations	1451	1309	1179	1323	1300
	Panel D: Outcomes Index Results without Including Educational Outcomes				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.120		--	--	--
	(0.122)				
Observations	1704				
Mean of Outcome	0.135				

Notes: Columns 1-5 present the results for different long-run outcome variables. Panel A presents results with no controls except for family, birth month, birth year and birth order fixed effects. The results in Panel B show the results from our primary specification when we do not impute opening and closing dates from tax records and just use the raw data. Panel C shows results when only using data from 1980-1998. Panel D shows results for the outcomes index when not including any educational outcomes. The location of the first birth is used for other children in the same family. In addition to family fixed effects, regressions in Panels B, C and D control for birth month and year, birth order, birth spacing, age in the last survey wave, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C10: Alternative Specifications and Comparison Groups

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Difference in Difference Results With Family Fixed Effects, for Children Conceived Within One Mile of a TRI site versus siblings in families 5 or more miles away				
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.144	0.0770	-0.244	-0.0176	-0.0112
	(0.152)	(0.0514)	(0.391)	(0.0544)	(0.0665)
Observations	2751	2756	2246	2459	2428
Mean of outcome	0.0671	0.381	13.25	0.840	0.610
	Panel B: 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				
(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)	-0.539***	0.179***	-1.127***	-0.123**	-0.0540
	(0.161)	(0.0688)	(0.429)	(0.0537)	(0.0631)
Observations	1448	1419	1171	1277	1258
Mean of outcome	0.123	0.373	13.40	0.847	0.630

Notes: Columns 1-5 present the results for different long-run outcome variables. Panel A depicts results with zip code fixed effects for non-movers. Panel B shows results with family fixed effects for being within 1 mile versus children living 5 or more miles away, including movers. In Panel C, 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, which compares siblings in families within 1 mile of an operating TRI site with siblings living 8-10 miles away. In addition to family fixed effects, all regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C11: 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) Low Birth Weight
	Panel A: Adjusting for Residential Sorting			
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.0732	0.0257	0.0432	-0.0765
	(0.0728)	(0.0243)	(0.0660)	(0.0516)
Observations	1704	1704	1704	1579
Mean of outcome	0.550	0.122	0.221	0.0817
	Panel B: Restricted to Non-Moving Families			
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.109	0.0155	0.0291	0.00532
	(0.0937)	(0.0204)	(0.0695)	(0.0488)
Observations	1,435	1,530	1,514	1354
Mean of outcome	0.548	0.115	0.201	0.0827

Notes: Columns 1-4 present the results for different long-run outcome variables. Panel A shows estimates from the specification in which the location of the first birth near a TRI site is used for all other children in the same family. Panel B shows results when restricting the sample to families who do not move between the births of 2 or more children. 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C12: Mediation Analysis

	(1) Outcomes Index	(2) Outcomes Index	(3) Outcomes Index	(4) Outcomes Index
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.284**	-0.341**	-0.325***	-0.329**
	(0.111)	(0.133)	(0.110)	(0.142)
Cognitive Disability	-2.014***			
	(0.259)			
Employed		0.912***		
		(0.0627)		
Years of Education			0.359***	
			(0.0147)	
Low Birth Weight				-0.220*
				(0.133)
Observations	1704	1704	1383	1383
Mean of Outcome	0.0870	0.0870	0.0870	0.0870

Notes: Columns 1-4 present results for the outcomes index when mediated by different possible channels. Standard errors are clustered at the TRI 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, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C13: Long-Run Outcomes by Treatment Intensity

	(1) Outcomes Index	(2) On Public Assistance	(3) Years of Education	(4) Completed High School	(5) Attended College
	Panel A: Stack Releases				
Conceived when TRI Site is Open	-0.334**	0.128**	-0.834*	-0.104	-0.0896
(Compared to Conceived When TRI was Closed)	(0.162)	(0.0645)	(0.463)	(0.0719)	(0.0841)
	Panel B: Fugitive Releases				
Conceived when TRI Site is Open	-0.417***	0.114**	-0.656*	-0.0564	-0.0505
(Compared to Conceived When TRI was Closed)	(0.128)	(0.0553)	(0.368)	(0.0561)	(0.0690)
P val stack=fugitive	0.279	0.0881*	0.144	0.190	0.333
Observations	1664	1619	1357	1499	1476
Mean of outcome	0.0856	0.381	13.29	0.832	0.615

Notes: Columns 1-5 present the results for different long-run outcome variables. In Panel A, we restrict to TRI sites reporting stack releases and in Panel B we restrict to TRI sites with fugitive releases. The estimates are from our preferred specification in which the location of the first birth near a TRI site is used for all other children in the same family. 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C14: The Effects of TRI Pollution by Industry and Pollution Type

	Outcomes Index			
	(1) All other Industries	(2) Metals	(3) Mechanical	(4) Plastic
	Panel A: Types of Industry			
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.300	-0.239	-0.550	-0.528
	(0.188)	(0.222)	(0.341)	(0.391)
P val compared to all other industries		0.825	0.494	0.604
Observations	1664	1664	1664	1664
	Panel B: Types of Pollution			
	(5) Heavy Metals	(6) VOCs	(7) All other TRI compounds	
Conceived when TRI Site is Open (Compared to Conceived When TRI was Closed)	-0.237	-0.191	-0.459***	
	(0.217)	(0.250)	(0.137)	
Observations	1704	1704	1704	
	Panel C: Amounts of Pollution			
	(8) All TRI Pollution			
Amount of Pollution Released When Child was Born (In Thousands of Pounds)	-0.00158*			
	(0.000806)			
Observations	1661			

Notes: Panel A of this table includes output from a single regression in which the effects of exposure to different types of TRI industries during gestation were estimated on the long run outcomes index. Panel B of this table also includes output from a single regression in which the effects of exposure to different types of pollution during gestation were estimated on long run outcomes. Panel C shows a regression of the outcomes index on the amount of pollution released in a child's birth year. The location of the first birth is instrumented for other children in the same family. In addition to family fixed effects, regressions control for birth month and year, birth order, birth spacing, age in the last survey wave, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C15: Limiting the Sample to Siblings Conceived When a Site Was Not Operating

	(1) Outcomes Index	(2) Years of Education
Second Born Siblings vs. First Born	-0.172	-0.391
	(0.115)	(0.263)
Third Born Sibling vs. First born	-0.0691	0.139
	(0.159)	(0.433)
Fourth+ Born Siblings vs. First Born	-0.389	0.193
	(0.296)	(0.712)
Observations	1062	879
Mean of Outcome	0.0261	13.14

Notes: Columns 1-2 present results for the outcomes index and years of education. Only siblings residing within a mile of a TRI site that was not operating are included in the analysis. The omitted category is being first born. Standard errors are clustered at the TRI 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, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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 C16: Correlation Between the Number of Times a Child is Observed in the Data and Child Characteristics

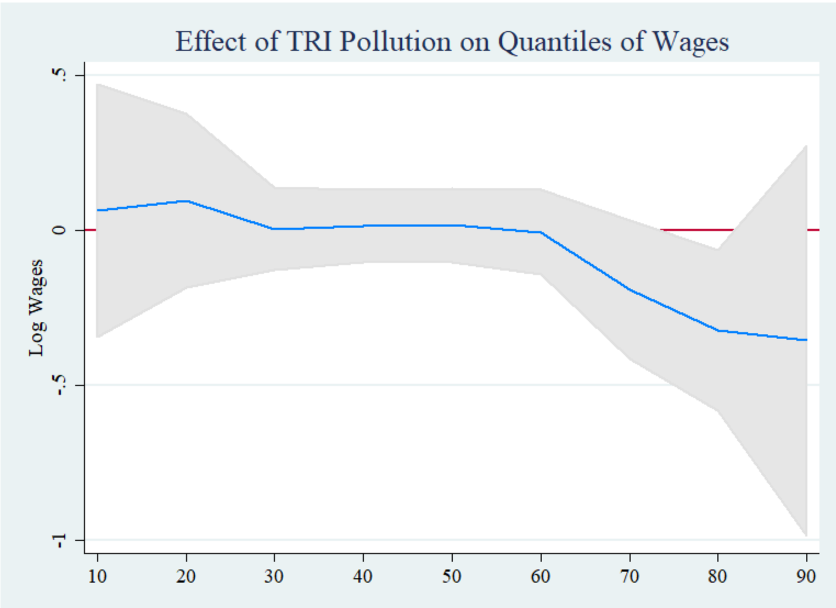
	(1) Black	(2) Hispanic	(3) Female	(4) Poverty Status in Birth Year	(5) Maternal Marriage Status	(6) Years of Childhood Poverty
Number of times in the data	0.000	0.000	0.0323***	-0.0137*	0.0112*	0.0421
	(0.000)	(0.000)	(0.0106)	(0.00727)	(0.00593)	(0.0308)
N	1898	1898	1898	1898	1898	1898
Mean of outcome	0.316	0.181	0.459	0.272	0.559	3.240

Notes: Columns 1-6 present the results of a correlational analysis of different child characteristics on the number of times that child appears in the data. 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, age squared, age cubed, maternal marriage status, maternal drinking, total years of childhood poverty, adult marital status 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.

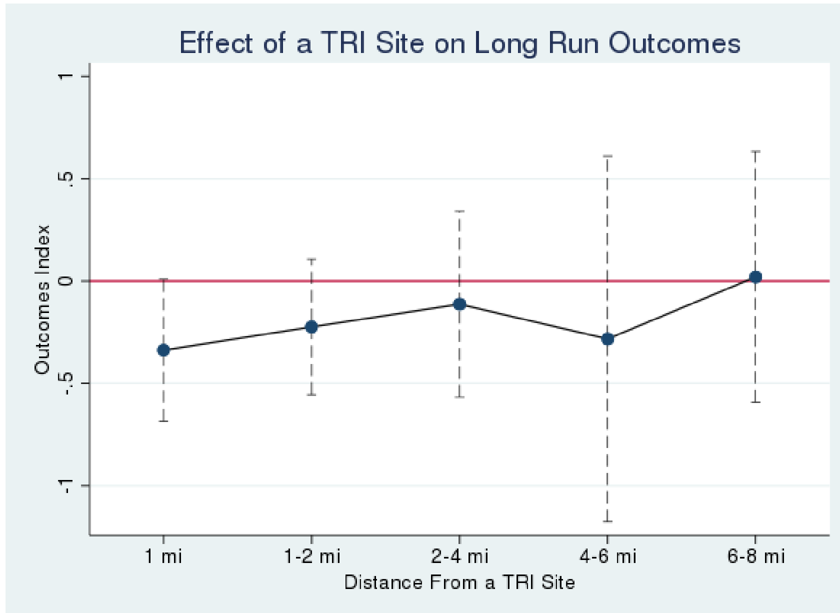
Figures

Figure C1: Effects of in Utero Exposure to TRI Pollution over Quantiles of Income and Outcomes with Family Fixed Effects for Gestational Exposure at Different Distances from a TRI site

Panel A



Panel B



Notes: Panel A of Figure 2 plots the effects of gestational exposure to TRI pollution on quantiles of the log of wages in adulthood. The line represents point estimates from a simultaneous quantile regression of the effects of gestational exposure to TRI pollution on wages, controlling for family fixed effects, birth month and year, birth order, birth spacing, age in the last survey wave, age squared, age cubed, maternal marriage status, total years of childhood poverty, adult marital status and gender. We also use the location of the first birth for all other children in the same family to address residential sorting. The shaded region represents 95% confidence intervals from bootstrapped standard errors. Panel B of Figure 2 plots the effects of in utero exposure to an operating TRI site at different distances away from the site. 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. Standard errors are adjusted for clustering at the site level; the vertical lines represent 95 percent confidence intervals.